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GEOLOGICAL SURVEY

—OF—

ALABAMA.

REPORT FOR THE YEARS 1881 AND 1882,

EMBRACING AN ACCOUNT OF THE

AGRICULTURAL FEATURES

OF THE STATE.

BY
EUGENE ALLEN SMITH, PH. D.,
STATE GEOLOGIST.

MONTGOMERY, ALA.:
W. D. BROWN & CO., STEAM POWER PRINTERS AND BOOK BINDERS.
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To His Excellency,

EDWARD A. O'NEAL,

Governor of Alabama:

SIR—With this I transmit my Report of Progress of the Geological Survey for the years 1881–1882.

I have the honor to be, sir,

Your obedient servant,

EUGENE A. SMITH,

State Geologist.

UNIVERSITY OF ALABAMA,

February 15, 1883.

101085

PREFACE.

The law organizing the Geological Survey, requires from the State Geologist, among other things, a report upon the Agricultural resources of Alabama.

The present volume has been prepared in obedience to this requirement; its special form and arrangement have been determined by the following circumstances:

In the year 1880 I was requested by Dr. Eugene W. Hilgard, in charge of the Cotton Culture Reports of the Tenth Census of the United States, to prepare the Volumes on Alabama and Florida. The plan of these volumes, as drawn up by Dr. Hilgard, was somewhat comprehensive, embracing, in addition to the special report on Cotton Production, a general discussion of the agricultural features, soils, etc., of the several cotton producing States, and as this plan covered substantially the ground contemplated in the State law above referred to, it seemed to me desirable to prepare the volume on Alabama with a view to using it as the basis of a State report.

The Superintendent of the Census, Gen. Francis A. Walker, with his usual liberality, very obligingly placed at my disposal for the use of the State, the maps and wood cuts engraved for the Census Office, together with the statistics collected by the enumerators; while on the other hand, the materials in the possession of the Geological Survey, collected by myself during the eight years of the present administration, were freely contributed to the Census Report. The summer seasons for the past four years have also been devoted to the collection of the data for this Report, the greater part of the expense in 1880–81, having been defrayed by the Census Office, and in 1882–83, by the State Geological Survey.

By this combination I have been enabled not only to make the Census Report on Alabama, in some respects fuller and more complete than the others of the series, but also at the same time, to secure for the present State Report, maps, illustrations, and other materials which would have required the *whole appropriation* allowed by the State *for many years*, if prepared solely at the expense of the Survey.

The present volume is, therefore, in no sense a mere reprint of a Census Document, but is a joint affair of the Census and of the Geological Survey. Under the auspices of the Survey, as above stated, the results of two years' field work have been added to those obtained for the

Census; about two-thirds of the chemical analyses have been made at the expense of the Survey; the charts of temperature and rainfall have been prepared by the Survey; and the whole of Part I, appears in this Report and not in the Census Report.

The following outline of the arrangement of the subject matter of the Report may be of service to the reader:

The special description of the soils of Alabama in Part II, is preceded in Part I, by a discussion of the composition, mode of formation, and properties of soils in general.

That something of this kind was needed for the completeness of the Report, and for the full understanding of many portions of the Special Part, is evident.

We know that the soils of Alabama, from whatever source derived, have all essentially the same constituents; and that over some portions of the State they show a suprising degree of uniformity in the relative proportions of their constituents. Whence have the materials of these soils come; by what agencies have they been prepared and distributed; how have the products of rock-disintegration come to assume the peculiar mechanical condition which characterizes soils; how have soils acquired those chemical qualities which distinguish them from the other solid parts of the earth's crust; upon what constituents do their remarkable properties of absorption, etc., depend; and by what means are they effected? These are questions which must interest every one who cares to look beyond the mere surface of things, and to answer them in some measure, has been my aim in the first part of the Report.

This part has been compiled from the latest and best sources, and will, it is hoped, be found to be an expression of the views at present prevailing upon the topics of which it treats.

Part II, is devoted to Alabama, and contains an account of the agricultural capabilities of the State, arranged as follows:

First, the tabulated results of the enumeration relating to area, population, and cotton production, and to the production of the leading crops. Then, in

Section I, An outline of the Physical geography and Geology of the State, and an enumeration of the Agricultural sub-divisions or Regions.

Section II contains a special description of these Agricultnral Regions, accompanied by analyses of the most characteristic soils and discussions of the analyses. As a matter of course, only the *great classes* of soils come under discussion, and not all the innumerable local varieties. The soils analyzed were collected by myself except those otherwise specially credited.

Next follows a list of the botanical and common names of the characteristic timber-trees and other plants of the several regions, including those giving most trouble to farmers, as weeds.

Section II concludes with some remarks on cotton culture in the State, in which the statistics are presented in tabular form, to show the relations of the several Regions in respect of area, population, and cotton production, and to compare these regions as regards their product

per acre and their respective contributions to the total production of the State.

Under each Region are also given the "banner" counties in regard to the product per acre and total production, and a general discussion of the areas of greatest production, of the relations between the population and cotton production, and the parts borne by the two races (white and black) in cotton production, with some inferences drawn concerning the effect on the soil, and on the yield, of the prevalent systems of farming. This is followed by a chapter on the use of fertilizers in cotton planting, and an account of the materials naturally occurring in Alabama, which have been, or which may hereafter be, used in the improvement of the soils.

Section III is devoted to the agricultural descriptions of the counties of the State, grouped under the several agricultural Regions described in Section II. When a county belongs to more than one of these divisions, it is described in connection with that Region with which it is thought to have most in common.

Each county description is preceded by a heading giving data relating to population, area, lands in cultivation, with the proportion devoted to each of the leading crops, but particularly to cotton, under which head are given the number of bales, the average product per acre, and the per centage of tilled land in cotton.

The statements of areas are based upon measurements, which have been made as accurately as possible, but they are to be considered only as approximations, since the lines separating the agricultural Regions are themselves to a certain extent conventional.

In the county descriptions, abstracts are given of the answers to the schedule questions relating to the soil varieties, their yield of seed-cotton when fresh, the most troublesome weeds, prevalent practice with regard to protection against injury from washes, etc.

The great discrepancy between the estimates of correspondents and the enumeration returns regarding the average yield of the soils, is more particularly noticed in the chapter devoted to remarks on cotton culture.

Section IV gives the details relating to culture, system of farming, etc., being an abstract (condensed, but containing all the essential material) of the answers to the schedule questions relating to tillage and improvement of land, planting and cultivation of cotton, ginning, baling, and shipping of the same, diseases and insect enemies, etc., and to labor and system of farming.

Acknowledgments of Indebtedness.—The works most frequently consulted in the preparation of the first part of this report have been referred to in the foot notes.

With respect to the second part, the sources of information are as follows:

The Geological Reports of Professor Tuomey, published in the years 1850 and 1858, respectively.

The Reports of Progress of the Geological Survey, made by myself, for the years 1874, 1875, 1876, 1877-78, and 1879-80.

Manuscript Notes of several excursions made by me in 1880 and 1881, under the auspices of the Census Office, and in 1882 and 1883, at the expense of the State Geological Survey, for the purpose of collecting soil specimens and certain data for this report.

The answers returned by correspondents from the various counties to whom were sent the schedules of questions relating to cotton culture.

From Dr. Charles Mohr, of Mobile, a special agent of the Census Office, I have received many valuable notes on the botany of the different parts of the State.

The county officers in various parts of the State have given, upon solicitation, much information regarding their own sections.

Free use has been made of the published bulletins of the Census Office.

Finally, all the chemical analyses for this, as well as for the other States embraced in the Census Reports on Cotton Production, were made in the Laboratory of the University of Alabama, under the direction of Dr. R. H. Loughridge and myself, with a few exceptions, by students in the Chemical Department of the University, and acknowledgments are due to these young men, Messrs. Henry McCalley, Chappell Cory, John B. Durrett, and Daniel W. Langdon, Jr., for several analyses appearing in this Report, made by them free of charge.

As already stated, two-thirds of the analyses presented herein were presented by the State Geological Survey, and made by the young men whose names have been given.

EUGENE A. SMITH.

University of Alabama.

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PART I.

A GENERAL DISCUSSION OF THE COMPOSITION, MODE OF FORMATION, AND PROPERTIES OF SOILS; AND OF THE CHANGES PRODUCED BY CULTIVATION.

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SECTION I.

THE SOIL IN ITS CHEMICAL AND GEOLOGICAL RELATIONS.

General Definition and Account of the Formation of Soils. Although the greater part of the rigid framework of the earth, so far as it is exposed to the observation of men, is made by the solid, hard, compact masses commonly called "rocks," yet these form but a very limited portion of the actual surface, for upon exposure to the atmospheric agencies, such as changes of temperature, frost, rain, etc., they are speedily broken up into fragments of greater or less size, which either rest upon the parent rock, or are washed off and deposited again at a distance.

In addition to these mechanical causes of destruction, there is a chemical action by which certain constituents of these rocks and rock fragments are either entirely or partially dissolved out and removed, leaving a remnant in the form of sand, or of a crumbling earthy substance which resists any further action of these forces.

In this way bare rocks in time become covered with a mass of loose material, resulting from their decay or washed down upon them.

And further, even upon a comparatively fresh rock surface, microscopic plants, chiefly lichens, attach themselves, corroding and rendering it friable and porous and better fitted to support other forms of vegetable life such as mosses and grasses. These soon take root and assist in the work of destruction thus begun. The remains of these plants are incorporated with the layer of earthy matter produced in the manner above described, thus adapting it to sustain still higher forms of plants, and introducing, in the acids and other products resulting from their decay, a new source of chemical action, by which the work of disintegration is greatly accelerated.

This uppermost or newest layer of the earth's crust, which supports vegetation and consists of a mixture of the still undecomposed fragments of rock or of minerals, of the earthy material resulting from their chemical decomposition, and of decaying and decayed vegetable matter, the whole mass permeated with substances which the circulating waters have been able to dissolve out and diffuse, constitutes in the most general terms what is known as the soil.

An examination will usually show that the topmost layer differs in color, texture, and in many other respects from that immediately underlying it. It is commonly of darker color, looser texture, contains more vegetable matter, and in cultivation is turned up by the plow and more thoroughly exposed to the action of the atmosphere. To this top layer the name *soil* is usually restricted, while the immediately underlying mass, which is mostly beyond the reach of the plow, has the general name of *subsoil.**

If only the *disintegrating action* of the atmospheric forces were concerned in soil formation, we should find everywhere that the soil was merely the decayed portion of the rock lying beneath it; but this, as is well known, is very far from being the case; for so soon as differences of level occur, the products of this decomposition will inevitably be washed down to lower positions by the rains, and thus *transported* by running water to greater or less distance, will come to rest again upon other rocks than those from which they were derived. And no less certainly will the act of transportation be accompanied by a re-arrangement of the materials, and a more or less complete separation of the coarser from the finer particles. A distinction is thus necessarily to be made between *primitive* or *sedentary soils* which rest directly upon the parent rocks, and *transported* or *secondary* or *sedimentary soils* which have been removed from their place of origin.

It is evident, further, that upon any sloping surface only a portion of the detritus arising from the disintegration of

*The soil is sometimes defined as the layer or stratum penetrated by the roots of plants, and from which they derive their nourishment. From this point of view, the very same stratum may be *soil* with reference to one class of plants, and *subsoil*, with reference to another.

the rocks will remain as a soil; the rest will be carried down by rivulets, brooks, and rivers, into the sea. The coarser particles which have not been dropped on the way will be deposited in the still waters close to the shores, while the finer sediments will remain longer in suspension and be distributed far and wide over the sea bottom, but still at no very great distances from the shores. The other materials which have been taken into solution and reach the sea in this way can be preciptitated out of the dissolving water only by means of some chemical reaction, or through the agency of some kind of organism.

The sediments which, in any of the ways above mentioned, are deposited upon the sea bottom, are in time converted into rocks by the accession of some kind of cement which binds the particles together.

By the secular movements of the earth's crust, these newly formed rocks may be lifted above the sea and added to the dry land, to be again subjected to the corroding action of the weather, to be again broken down and crumbled into soils.

Such is a broad general outline of the processes concerned in the formation of soils. These processes, as we see, are—disintegration, transportation, deposition, consolidation—then disintegration again, and so on in a never ending series. So far as the material is concerned, which actually comes under the observation of men, Prof. Leconte has said, "We certainly never see any soil that has not been rock, nor any rock that has not been soil. We never see any stratified rock that has not been igneous rock, nor, I believe, any igneous rock that has not become so by refusion of stratified rock. Thus the whole material of the earth crust has been worked over and over again many times, passing thus through a perpetual cycle of changes."

In other words, the work of the forces of nature is a tearing down and a re-building; a conversion of rock into soil, and a conversion of soil into rock.

Each of these we shall consider in turn, but first, in order to see for what materials the soils are indebted to the rocks, and for what—to other sources, we shall give the elementary

composition of soils, and then that of the various kinds of rocks.

CHEMICAL ELEMENTS OCCURRING IN SOILS; INORGANIC AND ORGANIC.

Of the sixty-four simple or elementary substances at present known to chemists, comparatively few enter into the composition of soils and of plants and animals. Leaving out of account for the present, those substances which occur only in minute traces, these elements are the following:

Hydrogen,	Potassium,
Nitrogen,	Sodium,
Carbon,	Calcium,
Oxygen,	Magnesium,
Silicium,	Iron,
Sulphur,	Manganese,
Phosphorus,	Aluminium.
Chlorine.	

The first column includes the *non-metallic*, the second, the *metallic* elements. The hydrogen, nitrogen, carbon, and in part also the oxygen, are assimilated by plants, directly or indirectly from the atmosphere, and in the remains of these plants or of the animals feeding upon them, become incorporated into the soil; they are for this reason sometimes called the *organic elements*, and they make up by far the greater proportion of the weight both of animals and plants.

The others, or the *inorganic elements*, compose the incombustible parts or ashes of both animals and plants, and make up also the greater part of the soils.

In addition to the above, the ashes of plants have, in some cases, been known to contain of the non-metallic elements, arsenic, titanium, boron, bromine, iodine, and fluorine; and of the metals, lithium, rubidium, barium, strontium, zinc, cobalt, nickel, and copper.

The soil also, in exceptional cases, may contain traces of all these and perhaps of other elements, which are, however, not only not essential, but often even prejudicial to the growth of plants. For these reasons the preceding list may be considered as including all the chemical elements essen-

tial to the composition of a soil and of the plants to which it gives support.

These elements combine together forming a number of compounds, the most important of which, for our purposes, are the following: Compounds of the various elements with oxygen, which are called *oxides;* with sulphur, called *sulphides;* with chlorine, *chlorides*, etc. The non-metallic oxides combine with water (itself a compound of oxygen and hydrogen), forming what are known as acids; and the compounds of metallic oxides with water constitute the *bases;* while the compounds of the acid and basic oxides are called *salts*, a name applied also to the *chlorides*, *bromides*, and similar substances.

The salts are usually named from the acid which they contain; thus, sulphuric acid combines with the metallic bases forming the *sulphates;* nitric acid forms in a similar way the *nitrates;* carbonic acid, the *carbonates;* silicic acid, the *silicates*, etc.

I. Source of the Inorganic or Purely Mineral Ingredients of Soils.

Chemical Compounds Existing in all Rocks.—Nothwithstanding the great variety in the materials which form the solid crust of the earth, and from which the inorganic constituents of soils are derived, they may yet, so far as their chemical character is concerned, be brought together in comparatively few groups; which, excluding the metallic ores, (except those of iron and manganese), are the following:

Silicic oxide, or *silica*, in the free state or uncombined, in a number of forms and modifications, as quartz, soluble silica, etc.

Silicic oxide in combination with metallic bases constituting the *silicates*, the most important of which are the silicates of alumina; of the alkalies (potash and soda); of the alkaline earths (lime and magnesia); and those of iron and manganese.

The *oxides* of these two metals, and their *carbonates* and *sulphides;* the *carbonate of lime*, crystallized in various forms, or amorphous, or in the form of organic remains (shells, etc.); *carbonate magnesia*, either alone or combined with carbonate of lime in the mineral called *dolomite; sulphate of lime* or *gypsum; chloride of sodium* or *common salt;* and in addition to these a number of other substances in minute

quantities either contained in the above or sometimes forming distinct minerals, such as compounds of iodine, chlorine, phosphorus, and traces of a great number of metals.*

Geology teaches us that the eruptive, or primitive, or original rocks, from which directly or indirectly all the others have been derived, are all silicates; while the secondary or sedimentary rocks, whether crystalline or not, are either quartz rocks, or silicates, or those which consist of carbonate of lime (limestone), or of carbonate of lime and magnesia (dolomites). The other chemical compounds noted above, play a comparatively unimportant part in the formation of rock masses.

That these teachings are borne out in our own State, may be seen from the following summary of the chemical composition of the principal classes of rocks which make up the different geological formations of Alabama; and which furnish the materials for our soils.

These rocks, with the exception to be noted below, are all of sedimentary origin, that is, they have been formed out of the detritus of some previously existing rocks; but some of them have been changed from their original condition of ordinary sediments, have become crystalline aggregates of distinct and well characterized minerals, retaining, however, in most cases, the laminated structure due to their mode of formation.

Within the region of these altered or metamorphic rocks, as they are technically called, are others just referred to of extremely limited occurrence, also crystalline, but not (immediately at least,) of sedimentary origin, since they show by their position and structure, that they have been forced while in a melted state, into the fissures of the older rocks, where they have solidified. These *trap* rocks, or eruptive rocks, as they are called, have similar composition to some of the metamorphic rocks above spoken of, and the two classes may therefore be treated together.

Indeed, they are nothing more than sedimentary rocks (crystalline or other), melted and then solidified, taking on crystalline structure upon solidification.

The crystalline or metamorphic rocks consist of silicates of

*Mulder, Chemie der Ackerkrume.

lime, magnesia, potash, soda, iron, manganese, and alumina, and these are usually more or less mixed with free quartz or silica.

The non-crystalline strata which make the Silurian, Devonian, Carboniferous and later formations, are all either sandstones, shales, clays, or loose sands, derived from the disintegration of the crystalline rocks, and hence containing the same materials—or else they are limestones or dolomites, which are carbonates of lime, or of lime and magnesia, usually more or less mixed with earthy matter.

In this summary of the chemical composition of the principal varieties of rocks, no mention has yet been made of the occurrence of sulphur, phosphorus, or chlorine, although these elements are regularly found in all soils.

Recent investigations have shown that phosphorus is a regular constituent of all crystalline rocks, usually in the form of phosphate of lime, while in sedimentary non-crystalline rocks, its mineralogical form is often different.

And similarly with respect to sulphur; in all the crystalline rocks, sulphuric acid is found when carefully looked for, and in addition sulphur in the form of pyrites or iron sulphide, is one of the most common of the accidental or accessory ingredients of the rocks of all ages.

The most of the crystalline rocks also, when pulverized and extracted with water, yield small traces of chlorine in the form of sodium chloride or common salt. The minute traces of chlorine usually found in soils, are accounted for when we consider the easy solubility of the great majority of the compounds of chlorine, which are, for this reason, rapidly leached out of the soil and carried down to the sea.

A. Conversion of Rock into Soil.

Any of the strata above named may lie at the surface, and upon exposure to the atmospheric agencies, be transformed into soil; and in fact many of the beds above enumerated in Alabama, as well as those which constitute the solid crust of the earth everywhere, have in the past served as soils and supported vegetation as may be seen in the remains of this vegetation imbedded in them in the form of fragments and impressions of leaves, stems, bark, etc.; of brown coal or lignite; of bituminous and anthracite coal; and even the crystalline rocks which are farthest removed from ordinary soils in their physical structure, contain the remains of vegetable life in the form of graphite or black lead.

But none of these rocks, not even the ancient soils above spoken of when broken up and pulverized by *merely mechan-*

ical means, are fit to serve again as soils, for rock powder is not soil. To this end certain chemical changes are first needed, such as are brought about by exposure to the atmosphere, and which are expressed by the term "weathering."

(I.) Action of the Atmospheric Agencies in causing the Disintegration of Rocks. Weathering.

The agencies by which rocks are disintegrated are of two kinds, mechanical and chemical. The former, which include changes of temperature, the enormous force exerted by water in freezing, and the force exerted by falling rain, have the effect of merely mechanically breaking up and pulverizing the rocks. Of these agencies, frost is perhaps the most important, for water penetrating the pores and clefts in rocks and there freezing, exerts a force which is practically irresistible. These mechanical agencies act upon all rocks alike, their effect being simply to overcome cohesion.

With the chemical agencies, the case is very different, and the effects produced upon the rock, as well as the character of the resulting material, will depend solely upon the chemical and mineralogical composition of the rock acted on. These chemical effects are produced by the combined influence of water, carbonic acid, oxygen, and the salts held in solution in atmospheric waters. (Johnson, How Crops Feed.)

It is said above that there is no rock that has not been soil, that is, no rock at present exposed to the observation of men; where then shall one begin in describing the processes by which rock is converted into soil?

According to the very generally accepted theory of the earth there must have been an *original, primitive rock*, the first solid crust formed by cooling of the melted matter composing the body of the earth. There is no probability that any portion of this original rock has ever been seen, it having doubtless passed through many cycles of change before the earth became the home of man. But it is reasonable to suppose that the materials of this primitive rock, when again melted and solidified, would still retain approximately the same characters as the original crust

which was produced in a similar way; that they would form rock masses very similar to the original rock, and that these newer rocks would yield very similar products as result of weathering.

The lowermost and oldest rocks which have been examined, everywhere give evidence of having once been in a fused or at least pasty condition, which permitted the formation of definite chemical compounds out of the mass of materials composing the rock; each such definite compound assuming on solidification, a regular crystalline form, so that whatever may have been the physical characters of the mass *before* fusion, *afterwards*, it became an aggregate of crystallized minerals, *i. e.* a crystalline rock.

For these and other reasons the crystalline rocks naturally form the starting point of any description of soil formation.

VARYING CHEMICAL AND MINERALOGICAL COMPOSITION OF THE CRYSTALLINE ROCKS.—The principal constituent of all these rocks, is *silicic acid, or silica,* there being hardly one in which this ingredient does not constitute nearly half its weight; next in importance is *alumina,* constituting 10 to 20 per cent.; and in addition to these, the oxides of *iron, manganese, lime, magnesia, potash,* and *soda,* in variable and usually small proportions.

According to the varying proportion which they contain of these different ingredients, these rocks have been arranged in two classes, which while not separated by absolutely fixed limits, are still in general sufficiently distinct in their characters.

In the one class there is a preponderance of silica or silicic acid, and the rocks are hence called *acid silicates.* The other class is poor in silica, and the rocks belonging to it are called *basic silicates.*

The first group contains small quantities of iron, lime, and magnesia; the other a large proportion of the same. The first is rich, the second poor in alkalies.

These two classes of rocks behave very differently in weathering, and bear very different parts in furnishing the materials for soils.*

The rocks of the first class, which have also been called the *aluminous-alkaline silicates,* so far as they occur in Alabama, are chiefly granites, gneisses, and mica slates.

The chemical composition of this group, according to Mayer, varies as shown by the following figures:

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*Mayer, Agricultur Chemie.

Silica	54	to	79	per cent.
Alumina	10	"	23	"
Ferric Oxide	0.8	"	7	"
Manganese	0	"	0.5	"
Lime	0.1	"	4	"
Magnesia	0.1	"	1.5	"
Potash	1.3	"	8	"
Soda	0.4	"	9	"
Water	0.4	"	1.5	"

The second or basic class (*iron-lime silicates*), including the hornblendic and augitic rocks, has, according to the same authority, the following average chemical composition:

Silica	42	to	63	per cent.
Alumina	10	"	21	"
Iron Oxides	4	"	17	"
Manganese	0	"	0.5	"
Lime	1.8	"	15	"
Magnesia	1.1	"	11	"
Potash	0.1	"	8	"
Soda	0.2	"	8	"
Water	0.2	"	3.3	"

But since the silicic acid and the metallic oxides above enumerated combine together in many proportions, forming a number of different minerals, which offer very different degrees of resistance to the forces of disintegration, and yield very different materials as the result of the disintegration, it is impossible to get a clear idea of the process of weathering of the crystalline rocks, and of the products of their decay, without some knowledge of the special grouping of their chemical constituents—that is, of their mineralogical composition.

The rocks of the first group above given are composed of quartz—*i. e.*, silica or silicic acid in the free or uncombined state, and of silicates—*i. e.*, compounds of silica with bases, the most important of which are feldspar and mica, which are essentially silicates of alumina, and of potash, soda, lime, or magnesia.

Those of the second class never contain free quartz or uncombined silica, but are aggregates of feldspars (especially those containing lime and soda) and hornblende or augite, minerals which are essentially silicates of iron, lime, and magnesia, with little or no alkalies.

The presence of the alkaline feldspars—*i. e.*, those containing potash or soda—is throughout characteristic of the first class; while hornblende and augite are no less characteristic of the second class.

With the exception of the igneous rocks, above spoken of

as filling the fissures in other rocks of the metamorphic region, none of the typical rocks of the second class are found in Alabama, but most of the rocks which contain the iron-lime silicates, contain also free quartz, and, therefore, partake of the characters of both classes. Of the first or alkaline silicate class, we have many representatives.

GENERAL RESULTS OF WEATHERING.—The process of decomposition of rocks under the action of the atmospheric forces, has been described by Senft (Gesteins- und Bodenkunde) as consisting of three steps.

1st. By reason of daily and seasonal changes of temperature, and the action of frost, the rock mass is cracked and fissured in every direction, and often crumbled and broken down completely.

2d. As soon as fissures are formed in the mass of the rock, then begins the second act of the weathering: meteoric water in the form of vapor, dew or rain, penetrates into all these fissures, and into the capillary crevices thus produced, coming in contact with the smallest particles of the mineral constituents of the rock, thoroughly moistening and combining with them (hydration), thus bringing them into a condition to be most thoroughly affected by the chemical agents of the atmosphere.

3d. When the particles are thus thoroughly moistened, chemical action begins; carbonic acid and oxygen held in solution by the penetrating water, attack certain ingredients; the lower oxide of iron is further oxidized, and as hydrated ferric oxide, removed from its previous combinations; the alkaline silicates are dissolved, partly without change, partly as carbonates; the alkaline earths (lime and magnesia) are dissolved out as carbonates, and this process of extraction goes on till there remains of the original rock only a residue which is incapable of further alteration by these agents.

From the above, it will be seen that every mixed crystalline rock, by its disintegration under the action of the weather, yields the following products (Senft, l. c.):

1st. The rock is mechanically crumbled into a mass of fragments called sand or gravel, according to size, which may consist of pieces of the original rock, or of any or all of the constituent minerals of the same. This sand may be capable of still further change under the action of the agencies above enumerated, and in process of time may be wholly or partially disintegrated; or it may be permanent, no longer affected by the atmospheric agencies. This is the true sand.

2d. By the action of the carbonic acid and oxygen upon these rock fragments, certain constituents are brought into solution, or otherwise extracted or removed. The soluble salts thus removed consist of carbonates or silicates, and vary with the character of the original rock. The hydrated oxide of iron formed as above, being insoluble, is mechanically removed.

3d. After all the substances soluble in the meteoric waters have thus

been extracted, there remains as last product of the weathering a residue of quartz sand and clay, or some form of impure clay stained with iron and mingled with fragments of minerals which are with difficulty decomposed.

VARIATIONS IN THE PRODUCTS OF WEATHERING.—The quality of these products will, of course, vary with the mineralogical composition of the rocks yielding them, but their general character may best be seen by tracing the progress of weathering of the constituent minerals of the two chief rock classes above defined.

The constituents of the first class (aluminous-alkaline silicates) are quartz, feldspar, and mica. Of these, the *quartz* being fully oxidized, practically insoluble in water, and indifferent to carbonic and other acids, resists the chemical action of the atmospheric agencies, and yields only to the mechanical forces above mentioned, by which it is simply broken up into coarser or finer particles, which constitute the greater part of the sand and gravel of the ordinary soil. But even quartz is not absolutely insoluble, though it is dissolved in meteoric water with almost inconceivable slowness.

The *feldspar* is the chief seat of chemical action; first becoming thoroughly moistened by imbibition of water, its alkalies are leached out by the carbonated waters, first as silicates, which are afterwards changed by further action of these waters into carbonates, with separation of the silicic acid in soluble form. The residue from this leaching consists of a soft pulverulent whitish or yellowish mass of hydrated silicate of alumina, which is practically insoluble, and which has the name of *kaolin* or *kaolinite*. The following table, taken from Johnson's How Crops Feed, shows very clearly the steps in the conversion of feldspar into kaolin:

	Feldspar.	Added.	Dissolved Out.	Kaolin.
Alumina.....	18.3	...	0.0	18.3
Silica.....	64.8	...	41.8	23.0
Potash.....	16.9	...	16.9	....
Water	....	6.4	....	6.4
	100.0	6.4	58.7	47.7

Other varieties of feldspar contain soda or lime, instead of or associated with potash, and the portion dissolved out will vary accordingly. Most feldspars contain also some small trace of iron. It seldom happens that the soluble salts are so completely leached out of the kaolin as the table would indicate; but portions of the silica, alkalies, and lime, and oxide of iron, are nearly always retained.

The ordinary clays consist of kaolin rendered more or less impure by admixtures of free silica, oxides and silicates of iron and manganese, carbonate of lime, and fragments or fine powder of various undecomposed minerals. (Johnson, l. c.)

The *mica* resists decay much better than the feldspar, but gradually loses

its alkalies and becomes a mass of impure kaolin stained or impregnated with iron, and of yellow or red color. The clay thus formed usually contains scales of the undecayed mica, as well as free silica, and a number of other substances due to accidental impurities, or to the varying composition of the original mica.

The end result, therefore, of the weathering of the rocks of the first class, is a pulverulent mass of impure kaolin, more or less colored with iron, mingled with scales of mica, grains of quartz, and fragments of the original rock, or of its constituent minerals, the whole permeated with solutions of the alkalies and of soluble silica.

The typical rocks of the second class (iron-lime silicates) consist of some variety of feldspar (usually those containing soda and lime), with hornblende or augite. In these also the *feldspar* is the chief seat of chemical action, the soluble portion being, however, mostly carbonate of lime or soda, the result of decay being otherwise similar to that above given.

The decay of the *hornblendic* mineral, after its hydration, usually begins with the oxidation of the lower oxide of iron (ferrous oxide), into ferric oxide, and its removal as hydrated ferric oxide, in which form it is either disseminated as coloring matter of the other products of disintegration, or concentrated by the action of decaying vegetable matter, into beds of brown iron ore or bog ore.

The lime and magnesia and alkalies of the hornblende are dissolved as carbonates, the proportion of alkali being usually small in comparison with the lime and magnesia. The majority of the hornblendic minerals contain some alumina, but in much smaller proportion than the feldspars, and the residue left after the removal of the soluble portion is a kind of clay, never kaolin, but always containing a surplus of silica, which is colored with the ferric oxide, and more or less impregnated with the carbonates of lime, magnesia, and soda, and with soluble silica.

From this it will be seen that the rocks of the second class yield by their decay, a ferruginous clay, permeated with solutions of the carbonates of lime, magnesia, and soda, and with silica.

The great majority of the crystalline rocks of Alabama are, however, in mineralogical composition intermediate between the two classes above given as extremes, and it is apparent that in weathering they all yield substantially the same result, viz., a mass of clay usually colored with oxide of iron, and mingled with sand or quartz grains, and fragments of the undecayed rock or of its constituent minerals, and impregnated with the materials dissolved out by the carbonated water, and these are potash, soda, lime, magne

sia, and iron carbonates, and soluable silica. The exact quality of the leached residue, and of the soluble salts or extract, as well as their relative proportions will depend upon the minerological character of the original rock.

When separated according to the coarseness of the grain, the materials yielded by the disintegration of rocks, consist of the fragments of rock and minerals, the result of mechanical disintegration, and the finely pulverized material which is the product of the chemical decomposition; the former may be called the skeleton or frame-work of the soil, the latter the fine earth.

The rock fragments or *gravel*, and the mineral fragments or *sand*, may consist of quartz or some similar material which is not capable of further alteration, and this is usually the case with sand; or they may consist of undecomposed, but *still decomposable* material, in which case they constitute a sort of reserve from which a supply of soluble salts may continually be extracted.

The fine earth or product of chemical decomposition, is a material of almost impalpable fineness, and consists of some form of usually impure clay, mingled with silica in a similar state of fine division, together with a part of the materials which have been leached out of the decaying rock by the solvent action of carbonated waters.

With regard to this soluble extract, which consists of silica, and compounds of potash, soda, lime, magnesia, iron and some other substances, it is evident that they are in some way withdrawn soon from solution, else they would very speedily be removed entirely from the soil, and carried down to the sea by the circulating waters. The manner in which these salts, especially such as serve as food for plants, are withdrawn from solution and fixed by the soil, is a subject of great importance, and one which has long held the attention of investigators. It will be considered below in connection with certain physical properties of the soil, and it suffices at this point to say that silica, alumina, the alkalies, and the alkaline earths show a great tendency to combine together forming a number of hydrous silicates of complex constitution, which are analogous to a class of minerals called *zeolites*. These, while not directly very soluble in water, are remarkable for their susceptibility to chemical change, and for the readiness with which they yield up certain of their constituents and take in new ones under the action of the various soluble salts contained in the water of the soil.

PRIMITIVE SOILS.—This "mixture of broken or pulverized rocks, with the products of their alteration by weathering,"

constitutes a soil, or at least its mineral or inorganic portion, which, in so far as it rests upon the rock from which it was derived, is called a *primitive* or *sedentary soil.*

The depth to which decay reaches is, in some instances, very great. In parts of the metamorphic region of Alabama, the "rotten slates," or "stratified clays," may often be penetrated for twenty feet, before the solid rock is reached.

In these decayed rocks the varying powers of resistance to decay of the different constituent minerals, is well illustrated. The feldspathic and hornblendic minerals are usually reduced to the condition of reddish clays, in which are scattered scales of mica, often quite fresh in appearance, while the seams of quartz interbedded with the other strata remain apparently quite untouched by decay, but are only broken down into fragments by mechanical forces. In these fragments we find the material for the greater part of our pebbles.

(2.) Mechanical Action of Water and other Denuding Agencies in Removing the Waste Produced by Weathering. Transportation.

The loose surface material which accumulates upon the rocks by the action of the forces above spoken of, is very speedily set in motion; a part of it is spread upon the land at a distance from its place of origin, while another part comes to rest only after being carried down to the sea or other bodies of still water.

Each of these portions bears its part in the formation of soils, and each will be considered in turn.

REMOVAL OF SOIL FROM HIGHER TO LOWER LEVELS.—In hilly districts the earthy and stony matter produced by weathering rolls down hill by its own weight, is driven by the winds, or washed by the rains, and thus, in various ways, is removed from its place of origin. By far the most important of these transporting agencies, so far as soil formation is concerned, is moving water.

ALLUVIAL SOILS AND SEDIMENTS.—Every falling rain washes

away from the summits and slopes of the hills and other elevations a part of the disintegrated rock.

The quantity and size of the material thus set in motion will depend upon the volume of the water, the angle of the slope, and the amount of the protection afforded by trees and other vegetation.

As this sediment-laden water flows downward a portion of it collects into rills and rivulets, and flows away by more or less well defined channels to some permanent water-course. Another portion, overflowing the narrow limits of these temporary channels, spreads itself on either side, where its velocity is gradually checked by its absorption into the ground, and by decrease in the angle of the slope. Some of the sediment will thus be deposited along the slopes, while upon the nearly level valley lands at the foot of the hills, the greater part even of the finest sediment will come to rest.

In this way a part of the rock debris is removed only a short distance and re-deposited upon rocks of similar nature to those from which it was originally derived, and in this respect it may resemble a primitive soil; but it is easily seen that the least change of position of the products of rock decay, by the agency of running water, will be attended with a change in the original proportions of coarse and fine material, *i. e.*, there will be a sorting of the material and a deposition of it in beds made up of particles and fragments of approximately equal size. In this rearrangement, the finely pulverized earthy matters will generally be washed down into the valleys, while the sand, pebbles, and blocks of larger size will be distributed along the slopes, in positions determined chiefly by the steepness of the declivity; the largest fragments being nearest the summits.

A large proportion of the loose materials taken up by rains will, however, be washed off into permanent streams and by them be transported far from their place of origin.

As the brooks flow together to form larger streams, each bears its tribute of soil and mineral matter washed from the lands which it drains. The sediment of a river thus includes material brought from all the various regions traversed by its tributaries.

In the attrition to which these materials are subjected in being rolled and dashed together by the force of the flowing stream, they will gradually be reduced in size, forming pebbles, and sand, and a part will even be ground down into an almost impalpable powder, which will differ from the fine material resulting from the chemical decay of the rocks, in having the same composition as the original rock, in being merely mechanically pulverized rock. In this grinding action, the softer and more destructible rocks and minerals will naturally suffer most, so that it cannot be surprising that the greater part of the material of pebbles and sand should consist of quartz, which is at once the hardest and the least liable to chemical decomposition of the constituents of our commonly occurring rocks.

With every diminution in the velocity of the current from change of slope or change of the volume of the water, or from the friction against the banks or bed of the stream, a part of the suspended materials will come to rest, the larger fragments and pebbles first, the sand and finer sediments last. In this way every stream from its source to its mouth forms a series of deposits of the materials washed into it or torn away from its banks; the coarser fragments in the upper part of its course, the smaller pebbles and grits and coarse sands in the middle part, the fine sands, silt and clay, at its mouth.

Where obstructions, such as islands or projecting points, occur at any part of the stream, eddies and moderately still water will be produced, and a gradual silting up will follow. The same thing happens on the concave side of every bend.

The current of a river is seldom so sluggish as to allow the deposition of the finest sediments, but gently flowing streams constantly leave along their banks where the retardation of the current by friction is greatest, a mixture of fine sand and clayey matter, or silt, such as the Loess of the Rhine and other rivers.

When, however, the waters rise out of the banks and spread over the flood plain, the matter held in suspension will be deposited in parallel zones; pebbles and sand on the immediate bank of the stream where the current is swiftest, and fine sand and clay further back in the river

swamp, where the comparative stillness of the water permits the complete settling of all the matter held in suspension. The soils of the river swamps thus accumulated, are of extraordinary fertility, but have the serious drawback that they are liable to periodical overflow.

Notwithstanding all this, a large proportion of the sand and finer sediments are carried down either in suspension in the central and swiftest part of the current, or rolled along the bottom, till the inflowing tide damming back the river stream produces still water, and permits the deposition of this suspended matter, forming a bar which may by gradual silting up become marsh and dry land.

The outflowing tide takes up again a part of this deposit and carries it out to sea where it comes to rest in the outer bar, or is carried far and wide, by the moving waves.

Where the waves break full upon the shore, they continually wash away the finer sediments leaving a beach of pebbles or sand, but where the shores are protected against the direct dash of the waves, as in bays, or where the waves break sideways on the shore, the fine silt and clay may gradually settle to the bottom.

Of course the sediments thus carried down to sea will be useless as soils unless reclaimed in some way.

This may happen by the gradual silting up of the shallow places till certain plants take root, and sea marshes are formed, or by means of dams, such places may be more speedily reclaimed and turned to the uses of men, as is often done in parts of Holland.

The rock fragments, the pebbles, the sand, the clay, and fine earth deposited in any of the ways above mentioned, in so far as they consist of material still liable to change under the action of the atmosphere, will be converted into pulverulent residue and soluble extract, in the manner already described, and thus gradually approach in appearance and in the nature of their constituent parts, the original or primitive soils before mentioned, but will differ from them in the circumstance that the materials for their formation have been brought from widely distant localities, and that they have necessarily no relation to the rocks upon which they may have been deposited.

SECOND BOTTOM DEPOSITS.—The rivers and other larger streams of Alabama, especially those traversing the drift-covered region of the State, flow along valleys of varying width (often four to eight miles), cut down into the rocks of the country (Cretaceous and Tertiary). The immediate channels of these streams, always more tortuous than the valleys above mentioned, are excavated out of materials which have evidently in the past been deposited by the stream itself, or at least by currents which once occupied the valleys between whose widely separated borders the present streams pursue their winding courses, touching these borders now on the one side, now on the other.

These Second Bottom deposits, or hummock lands, are always above overflow, and vary in thickness from sixty feet and upwards in the central parts of the State, to less than ten near the gulf. In composition they are surprisingly uniform, and no one familiar with our lower rivers, can fail to have noticed the monotony of the comparatively low bluffs which form the immediate bank, at least on one side of the river.

The first bottoms, or flood-plains, annually overflowed, form a narrow terrace on one or both sides of the stream, of course lower than the main mass of the Second Bottom deposits out of which they have been excavated.

The materials of the Second Bottoms are sand and clay in varying proportions; these present usually very indistinct marks of stratification, especially in the upper parts, which are commonly stiffer and more clayey than the lower. The following section of a Second Bottom exposed at Logan's Bluff, on the Warrior river, in Hale county, will give a fair idea of the average character of these deposits in the southern and central parts of the State:

(1). Top soil, six inches, grayish loam with a slight shade of yellow.

(2). From six inches to ten feet, the proportion of clay increases, and the material is a clayey loam of grayish yellow color.

(3). From ten to eighteen feet the proportion of sand increases, the deposit below ten feet being a fine sandy loam of decidedly yellowish or reddish color, mottled with

spots of light gray color, the sand grains quite small and rounded.

(4). From eighteen to twenty-five feet, yellowish or reddish sand, mottled with spots or streaks of gray to white sand, all very fine grained, comparatively little clay.

As before stated, the immediate channel of the stream is cut into this material, and the lower beds being much more sandy than the upper, there is a constant undermining and caving off going on on the outer side of the bends. The upper eight or ten feet of the bluffs thus produced, are usually nearly perpendicular and comparatively smooth, while below, the bank has a slope of forty-five degrees or less, along which the rains have cut little furrows and ridges.

As caving goes on, stumps and logs are frequently brought to view, which have been buried under these deposits. These are commonly supposed to be cypress stumps, and they are usually in a fair state of preservation.*

In some cases small beds of pebbles have been noticed underlying the Second Bottom deposits, but whether they were local river gravel, or Stratified Drift gravel, could not well be determined.

All the phenomena of the Second Bottom deposits, go to show that they are connected with the now existing systems of drainage, but were formed when the general level of the waters was higher than at present, or before the streams had cut their channels to the present depths. The Second Bottoms are less local in character, and less closely connected with existing streams than the First Bottoms; but, on the other hand, much more restricted and related to these streams, than are the various materials constituting the Stratified Drift, spoken of below as diluvial deposits.

The time of formation of the Second Bottom deposits, was probably intermediate between that of the Stratified Drift and of the recent First Bottoms; but in all these estimates

*This is partly on the authority of Capt. John Bartee, who has been a pilot on the Warrior River for many years, and who has also been engaged on the Government work in the Improvement of the River. I have myself seen these stumps at many points, apparently *in situ*, below 20-40 feet of Second Bottom deposits; but have never been perfectly sure that they were not more recent than their present position would seem to indicate.

we have only stratigraphy to guide us, the stumps above mentioned being the only organic remains which these deposits are known to contain.

Some of the most productive soils of Alabama are formed of these Second Bottom materials, and most of the celebrated river plantations of former times rest upon these deposits.

DILUVIAL OR DRIFT SOILS.—All the secondary soils accumulated in the ways above described, can in general be easily traced back to their sources; they have either suffered very little change of position, or if transported to considerable distances, have been carried along the courses of some well defined and now existing streams. But in Alabama and in many other countries, there are soil-forming sediments, spread with great uniformity of chemical and mineralogical composition over the formations of every geological age except the alluvial deposits just described. These sediments, like the alluvial, have no necessary connection with the rocks upon which they are now found, though in many cases to some extent modified by them, and their distribution is such as to preclude the idea that they have been transported and deposited by any stream at present existing. Indeed, many of the phenomena connected with these deposits, at least in Alabama, seem to be explicable only on the supposition that they were carried along and left by rapid currents of water, flowing from north to south, and spreading over the entire width of the State from east to west; and more than this, similar deposits in the adjoining States show that this great flood was not confined to narrow limits, but extended over the whole width of the Gulf States.

The materials of these beds, which are called from their mode of origin, Diluvial or Drift deposits, are pebbles, small gravel, sand, loam, and clay, sometimes in distinct beds, sometimes variously intermixed.

When all these beds are found together in one place, the pebbles very frequently lie at the bottom, then follow the sand, and at the surface an intimate mixture of sand and clayey matter or loam, usually colored deep yellow or red by iron.

From this their general order of superposition, it may be inferred that the rapidity of the transporting currents, at first very great, gradually diminished to the extent at least of allowing the deposition of the fine surface loam.

With this general order, however, the beds are often locally interstratified in such way as to give evidence of variations in the current, by which material once deposited, has been again taken up and re-deposited at a greater or less distance.

The different materials are not uniformly distributed, for the clay appears usually in somewhat limited masses of basin shape, as if deposited in eddies of still water along the courses of the great currents.

The pebbles in Alabama, are found, first, in a belt overlying and often concealing, the line of junction of the older and newer formations; and, second, stretching southward from this main bed in streams some twenty to thirty miles wide, which mostly appear to be connected with some at present existing line of drainage; third, intervening between these main streams are minor channels which have retained often small pebbles and gravel.

In other places the original surface has been overspread with sand and loam, which also, except where subsequently removed by denudation, cover the pebble deposits themselves.

In this way the red loam has come to be the substratum of the best upland soils of the southern half of the State, and its excellence is enhanced by the admirable underdrainage afforded by the beds of sand and pebbles, upon which it so often rests.

Origin of the materials.—The pebbles are mostly quartz, chert, or some other form of siliceous matter, which can in many cases be traced by the fossil impressions still observable upon them, to the siliceous beds occurring in the older formations of the State. It is very rarely the case that pebbles of other than siliceous matter, are found in the drift deposits of Alabama.

The sand consists also for the most part of rounded and water-worn grains of quartz, with which, however, flattened

and rounded grains of limonite or brown iron ore are not uncommon.

The clayey matter and the surface loam are such as might have been derived from the disintegration of many of the older rocks of the State, so that none of the material composing the Drift deposits of Alabama have necessarily been brought from beyond the limits of the State, though some of it may be foreign in its origin.

Position with reference to older formations.—These deposits lie upon a denuded surface, occupying the hills and valleys previously existing in the older formations, and the general features of the topography, all the most prominent elevations and depressions, water courses, etc., of the present were in existence when they were deposited. There are some circumstances, however, which seem to show that the floods which carried along the materials for these drift beds, were to some extent at least, instrumental in causing the denudation of the then existing land surface over which they flowed; for, in certain cases, these materials appear to be nothing more than fragments of the older rocks taken up and redeposited at no great distance from their original place. In such cases, there is naturally a very close connection between these deposits and the immediately underlying rocks.

Notwithstanding this, the Drift or Diluvial soils of Alabama may be looked upon as formed of material contributed by the most widely different rocks, including possibly those of every older formation occurring within the State, the whole thoroughly worked up and intermixed by the agency of moving waters to form a surface coating of vast extent and of surprising uniformity.

B. Conversion of Soil into Rock.

Formation of Stony Layers Beneath the Soil.—It is not uncommon to find in places below the soil, impervious masses of hardened clay or compacted sand or gravel, produced by the cementing together of the particles of the soil by solutions of the silicates or other compounds of lime, alumina, iron, and alkalies.

With us, the majority of these stony layers or *hard pans*, are formed through the agency of solutions of iron. This substance, in the state of the per-oxide, exists in most soils as coloring matter; by the agency of decaying organic matter it is reduced to the ferrous or protoxide state (in which condition it is soluble in atmospheric carbonated waters), and thus sinks through the soil into subsoil. There it is again re-oxidized, becomes insoluble, and binds together the soil or subsoil particles which it surrounds, into a hard, stony substance. This reconversion into rock of the loose materials of the soil, may often be seen in progress, where an impermeable stratum of clay arrests the downward course of solutions of iron, effected by the organic matters of the soil.

Many railroad cuts afford good illustrations of this kind of rock formation.

The basins of peat swamps, also, are frequently formed by thin layers of this hard pan. (Johnson).

It has been stated elsewhere that several of the silicates existing in all soils have a tendency to combine together as double salts to form insoluble compounds, and that the actual formation of these stony masses in the soil, is retarded or prevented by the admixture of organic matter and other indifferent substances, and also by frequent stirring and breaking up of the soil.

In the subsoil, however, the conditions are often favorable to the accumulation of these insoluble compounds, (which are double silicates of lime, alumina, or iron with alkaline silicates, and of the nature of zeolites), and they bear an important part in the production of hard-pan.

DEPOSITION OF SEDIMENT IN BODIES OF STILL WATER—MODE OF FORMATION OF BEDDED OR SEDIMENTARY ROCKS.—In the preceding sections we have spoken of the agencies which have contributed to the conversion of massive and slaty crystalline rocks, into soil, and by which this soil once formed, has been carried off and spread over other rocks than those which gave rise to them. We have next to see what becomes of the materials which are washed off entirely from the land and deposited in lakes and the sea. These materials consist not only of the solid particles carried along mechanically by the force of the moving water, but also that which has been dissolved by the water out of the soils and rocks over which it has flowed.

(1.) *From the matters mechanically carried.*—In the continual flow of waters from the high lands towards the sea, not only are the loose matters resulting from the decay of rocks still further broken up and comminuted, but they are sorted and deposited in beds according to the sizes of the individual fragments.

Naturally, the larger fragments and blocks, rarely reach the sea, and so rarely contribute to the formation of new rock masses. An accumulation of such large fragments is from the very coarseness of the material unfavorable to plant growth, and can form a useful soil only in proportion as these fragments undergo chemical decomposition.

Similarly the smaller rock fragments constituting the pebbles and gravel, are only in exceptional cases carried down to the sea.

The still smaller mineral fragments which we call sand, as we have already seen, is in great quantity, either in suspension or rolled along the bottom of the rivers, carried into the sea, where it comes to rest usually at no great distance from the shore. Here, either by filling up the channels, or the shallow parts along the shore, it forms directly new land, or it sinks to the bottom and is there converted into a new rock, *i. e.*, into sandstone, by simple pressure, or upon the accession of some kind of cement by which the sand grains are bound together.

The cementing principle of sandstones varies greatly, and may be clayey, siliceous, or calcareous, and it is this cement which distinguishes a sandstone from a mass of loose sand. No perfectly satisfactory explanation has, perhaps, yet been given of the hardening of these cementing principles; but it has many things in common with the hardening of artificial cements, which depends upon the formation of certain complex silicates of variable composition.*

The pebbles and small rock fragments, which, in some instances, are carried to the sea shore, may in a similar way become compacted into rocks which are called *conglomerates* or *breccias*, according as the rock fragments are rounded or angular.

*Mayer, Agrikultur Chemie.—See, also, above under formation of hard-pan.

As the result of the chemical decomposition of a great variety of crystalline rocks, there is, as shown above, a finely pulverized earthly substance to which the general name of *clay* has been given, since it consists, in great measure, of silicate of alumina. It is mostly impure, being mixed with a variety of other bodies, especially fine sand, and iron oxide. From its fine state of division, it is easily washed away by running waters, and for the most part, as we have seen, comes to rest only when the currents of the rivers are completely checked in mingling with the still water of the sea. Here it settles to the bottom, where, in some cases, it contributes directly to the formation of soils, *e. g.*, of sea marshes, etc., or coming to rest in deeper water, it may be compacted together in a manner analogous to that mentioned for sandstones, or perhaps by the simple pressure exerted by the superincumbent waters, forming rocks which are called clay slates, shales, etc. Rocks of this character, like the sandstones, occur among the sedimentary deposits of every geological age.

(2.) *From the matters carried in solution.*—Our account of the formation of new rock masses out of the products of the decomposition of the crystalline rocks, does not yet include a very important class of secondary rocks, viz: the limestones, and yet there is no geological formation which does not consist in part of limestones of greater or less degree of purity, and the material for their formation is undoubtedly furnished by these crystalline rocks.

Neither in the fragments which result from the mechanical disintegration of these rocks, nor in the usually finely divided or pulverulent residue left from their chemical decomposition, do we find any materials which when properly compacted would produce a limestone, and its source must, therefore, be looked for in the third class of products resulting from the decay of rocks, viz., the soluble extract.

This soluble extract, or the portion of the original rock dissolved out by the carbonated atmospheric water, in the case of those rocks which contain lime feldspars, and hornblendic minerals, is chiefly carbonate of lime and carbonate of magnesia.

In solution, they are carried by flowing streams to the

open sea, except when, by evaporation or chemical action, they are rendered insoluble and precipitated on the way, forming the so-called fresh water limestones.

The accumulation of lime carbonate in the ocean might go on in this way to the point of saturation, when it would be precipitated; and this actually happens in certain localities, especially near the mouths of certain rivers which carry down large quantities of carbonate of lime. It has, however, been calculated that the amount of carbonic acid in the sea water is more than sufficient to dissolve and hold in solution all the carbonate of lime now carried down by rivers, and the precipitation on a large scale of this salt by simple concentration seems not to be possible in the sea water as at present constituted.

But certain marine animals, such as corals, mollusks, etc., possess the power of abstracting from the sea water this carbonate of lime, and with it building up their shells, in which the lime is protected from the solvent action of the sea water by the animal matter with which it is usually enclosed, at least during the lifetime of the animal. Certain classes of plants also have a similar power.

By the accumulation of these organic remains, mostly after being broken up and comminuted, and even partly dissolved, with the partial or total obliteration of all organic structure, limestones are now certainly in process of formation, and have undoubtedly been formed in past geological periods, and it has come to be one of the generally accepted beliefs among geologists that the great masses of pure marine limestone have been formed through the agency of organic life.

Nearly all limestones contain *flint* or other *siliceous matter*, interbedded with the limestone layers, or else forming nodules and concretions in the same. Certain classes of organisms have the power of secreting silica from the sea water and incorporating it in their shells and other solid parts, and from these come probably all the siliceous accumulations so common in the various geological formations. *Glauconite* or *green sand*, so valuable as a fertilizer, also apparently owes its origin to some similar organic agency.

It has recently been shown that a deposit of *red clay* is in

process of formation in the deepest parts of the sea, and it is thought by some geologists that the material is of organic origin.*

Many of the materials which are dissolved out of the soil and carried down to the sea in solution, are not utilized by living organisms, and must, therefore, owe their precipitation in solid form to some other agency. Substances like common salt are precipitated out of solution only upon concentration or evaporation of the solvent. This is also to some extent true of gypsum. Such a degree of concentration can only be reached in isolated bodies of water, and not in the open sea.

The presence of immense beds of limestone among the rocks of the earliest geological formations, has led many geologists to conceive that the water of the primeval ocean differed from that of the present in the greater abundance of soluble salts of lime and magnesia, and that as solutions of the alkaline carbonates produced by the decomposition of feldspathic rocks were carried down to the sea by chemical reaction with the salts there held in solution, lime carbonate would be precipitated, and the alkaline carbonates converted into chlorides, in which form they would remain in solution.

The constant association of magnesia carbonate with limestone suggests a community of origin, but it is known that the shells of marine animals contain usually mere traces of magnesia, and the accumulation of beds of magnesian carbonates cannot, therefore, be referred to animal agency, but must be explained by some other reaction.

There is perhaps no subject which has more attracted the attention of geologists, and which has been more difficult of solution, than the explanation of the formation of magnesian carbonates. In many places these rocks are associated with beds of gypsum and rock salt, and as the latter is formed only in isolated lakes or portions of the sea, the same mode of formation is thought probable for the other two also.

Other explanations, based upon chemical reactions, have been proposed, but experiments which have been made to imitate the proposed reactions, have not always been successful. It has been suggested that carbonate of magnesia may have been produced by direct precipitation, either by the reaction of soluble salts of magnesia, such as the chloride, upon the carbonate of the alkalies, resulting in the formation of magnesian carbonate and potassium or sodium chloride, or by the reaction of sulphate of magnesia on carbonate of lime, producing lime sulphate or gypsum and magnesia carbonate. In either case, so long as any of the salts of lime remain in solution, the magnesia carbonate would not be thrown down. (Hunt, Chemical and Geological Essays.)

Another explanation assumes that beds of limestone exposed to the action

*A. H. Green, Physical Geology, p. 233.

of soluble magnesian salts have gradually been converted into magnesian, limestone or dolomite.

Whatever may have been the mode by which the carbonates of lime and of magnesia were deposited, the source is, according to Dr. Hunt, two-fold: 1st. Lime and magnesia silicates, such as feldspars and hornblendes; by the decomposition of which these bases as carbonates are brought into solution and thus carried down to the sea. 2d. The chlorides of lime and magnesia originally present in the waters of the ocean; by the reaction of which upon the carbonates of potash and soda, produced as above by the decomposition of feldspathic rocks, the lime and magnesia have been precipitated in the form of carbonates, while the alkalies, in the form of chlorides, have remained in solution, in this way bringing about secular changes in the composition of the sea water.

The clay or aluminous silicate deprived of its alkalies and alkaline earths, becomes thus a measure of the carbonic acid taken from the atmosphere, and of the carbonates of lime and magnesia precipitated and removed from, and the sodium chloride added to the waters of the primeval ocean. (Hunt, Chemical and Geological Surveys.)

The rare occurrence in beds or deposits of the other matters dissolved by ordinary meteoric waters, may in some cases (*e. g.*, the salts of potash and phosphoric acid) be in great measure explained by the avidity with which they are absorbed and retained by the soil, being thus rendered practically insoluble.

The Soils Derived from these Secondary Rocks.

The sediments accumulated in any of the ways above noted, and compacted into rocks, may, by the secular movements of the earth's crust, be again lifted above the sea and added to the dry land, to be again subjected to the corroding action of the weather, to be again broken down and crumbled. The cementing principle of the sandstones and conglomerates is loosened or dissolved by the carbonated water, the sand grains or pebbles fall apart; the clays will similarly be disintegrated, and the limestones will be acted on by the carbonic acid, and partially or wholly dissolved; in short, the sedimentary rocks will sooner or later be covered with a loose mass resulting from their disintegration or decomposition; but these products of decay will naturally be much nearer in composition to the parent rock than were the products of the decay of the original crystalline rocks.

The soil from a sandstone may be almost identical with

its parent rock in composition; the soil from a clay slate or shale may be identical in composition with the slate or shale.

And still further, the soils from such sedimentary rocks may also be removed from their original place, may be mingled with each other, may be redeposited on foreign rocks; in a word, all the phenomena may be repeated with the debris of these sedimentary or secondary rocks, which have already been described for the crystalline rocks.

We have here, however, a new feature in the occurrence of carbonate of lime (and of magnesia) in distinct beds, while heretofore its occurrence was only noted in small quantities held in solution by carbonic acid.

Beds of limestone, like other rocks when subjected to the action of the weather, are disintegrated and partly taken into solution, so that every stream which flows from a limestone region, may carry with it not only carbonate of lime in solution, but mechanically fragments of the limestone itself, which, in the form of lime sand or fine calcareous mud, may be mingled and deposited with sands and clays, producing such mixed sediments as marl, loess, etc.

With this, we may close our account of the formation of the inorganic or mineral portions of soils, and go on to the consideration of the modifications brought about by the action of organic matter.

Classification of Purely Mineral Soils.

When classified according to their purely mineral characters, all soils may be arranged as follows:*

I. Original or Primitive Soils—*i. e.*, such as till rests upon the parent rock.
   A. Those derived from the crystalline rocks.
      1. Feldspathic soils (from granite, etc.)
      2. Augitic and hornblendic soils (from basalt, dolerite, etc.)
      3. Micaceous or isinglass soils (from mica slate, gneiss, etc.)

* Mayer, Agricultur Chemie.

B. Those derived from non-crystalline, sedimentary or stratified rocks.

4. Sandstone soils (from the various sandstones).
5. Clay soils (from clay slate, shales, etc.)
6. Limestone soils (from limestone, dolomite, etc.)

II. Sedimentary, or secondary, or transported soils—*i. e.*, those which no longer rest upon the parent rock.

7. Pebbly and gravelly soils (from fragments of any kind of rock).
8. Sandy soils.
9. Clay soils.
10. Loam soils (containing mixtures of sand and clay).
11. Calcareous soils.
12. Marly soils (containing mixtures of lime and clay).

It will be readily understood that the above list is intended only to mark certain stages of an endlessly varied series actually existing in nature as the result of countless intermixtures.

II. The Organic Matter in Soils; Its Source and Characters.

A purely mineral soil produced in the manner above described, is not incapable of giving support to some kinds of plants, otherwise it would be impossible to explain the first appearance of vegetation upon the earth. In fact, it is a matter of common observation, that so soon as there is the slightest transformation of the surface of a rock by the atmospheric agencies, certain minute plant forms take root and flourish, finding even in this scanty soil enough of available mineral matter for their moderate needs.

But even with sufficient depth to give fitting support to the wide spreading roots of the higher orders of plants, a soil must contain other ingredients than those supplied solely through the decay of rocks, before it can furnish the nourishment which these higher plants demand.

These additional ingredients (chiefly some compounds of Nitrogen,) while coming ultimately from the atmosphere, are accumulated in the soil only through the agency of plants.

Besides, the incorporation into the soil of the remains of plants, imparts to it certain physical qualities which are of the utmost importance in fitting it to give support to other generations of plants. Indeed, it may be said that the decomposition products of rocks become *soil* only through the intervention of plants.

Action of the Living Plant.

This influence is exerted by the plant both while living and after its death. The living plant sends its roots into the fissures and crevices of rocks where, by their constant growth, they exert a force which is often sufficient to wedge off immense blocks. On the other hand, a conservative influence is seen where vegetation, by preventing the sudden rush of waters from the mountains into the valleys, and the consequent washing away of all the smaller products of rock decay, favors the accumulation of soil in regions where, otherwise, the surface would be a bare mass of rock fragments.

In marshes and other sufficiently shallow waters, a growth of marsh grass is often the starting point of a new land formation; and in some places the binding force exerted by the roots of certain hardy plants converts mere wastes of moving sand into arable soil.

A covering of vegetation, by preventing the escape of moisture and its attendant carbonic acid, greatly accelerates their solvent action upon the underlying soil, and it seems also probable that the roots of plants yield acid excretions which are not without their influence in corroding and dissolving the rock surfaces or soils with which they are in contact.

Action of Vegetable Matter in Process of Decay.

The real importance, however, of the plant as a factor in the production and modification of the soil begins with the cessation of its life.

When a plant dies its entire content of incombustible mineral matter, or ash, and of combustible organic matter is returned to the soil which gave it support. Upon the

decay of the plant these mineral matters, which have been taken up by its roots, often from considerable depths, and changed from insoluble to soluble forms, are returned to the top soil, in a condition most easy of assimilation by the succeeding generation of plants. The top soil is thus gradually enriched by the addition of those substances which count as plant food, such as potash, phosphoric acid, lime, etc., and it is not difficult to understand how forest trees, with their deeply penetrating roots, in bringing such plant food from considerable depths up to the surface may become efficient agents in the improvement and renovation of soil.

The organic element of the plant, consisting of carbon, hydrogen, oxygen, and nitrogen, (which, as already stated, have been mostly assimilated from the atmosphere,) are combined together to form a number of complex organic substances, more particularly described below. Upon the death of the plant these rapidly fall into decay, the end result of which, under ordinary circumstances, is their oxidation, i. e., their conversion into carbonic acid and water. Ammonia also is produced, which, sooner or later, is converted into nitric acid.

Concerning the *water* thus formed, nothing need be said; not so, however, with the other products named.

We have already seen that *carbonic acid* is one of the most important of the atmospheric agencies in promoting the chemical decomposition of rocks. Now when vegetable matter is incorporated with the soil, there is introduced into it a prolific source of carbonic acid. Analyses have shown that the air of a soil containing much vegetable matter is from twenty to one hundred times richer in carbonic acid than is the ordinary atmosphere, and it is obvious that in such soils, all those chemical changes which depend upon the action of carbonic acid, such as the decomposition of the unaltered, but still alterable, rock-fragments of the soil, and the changing of important elements of plant food, such as potash, phosphoric acid, etc., from insoluble forms into conditions in which they may be utilized by the growing plant, will go on with a rapidity and intensity which will be proportionate to quantity of vegetable matter present.

The nitrogenous portions of the plant, in the process of

the decay, are in part converted into *ammonia* and *nitric acid*, which also exert a decomposing action on the ingredients of the soil. And moreover, without the presence of one or the other of these substances, a soil is incapable of supporting a thrifty growth of vegetation, since it is tolerably well established that plants can assimilate nitrogen only when it is presented to their roots in the form of ammonia or nitric acid.

Humus.—But the influence of vegetable matter upon the soil is by no means even chiefly confined to these last products of decomposition, for in the course of this decomposition, several intermediate or transition products are formed partly acid, partly alkaline in nature, which react chemically most energetically upon the constituents of the soil and at the same time profoundly modify its physical characters.

These new organic compounds, the result of partial decay, are, notwithstanding the great differences existing among plants, essentially the same for all.

With the loss of part of its carbon and hydrogen in the form of carbonic acid and water, decaying vegetable matter is gradually converted into a yellowish or dark brown, pulverulent, carbonaceous mass to which the name of *humus* is generally given.

Humus is not a definite chemical compound of invariable composition, nor yet a mixture of such compounds, but it is rather a mixture of partially decomposed vegetable matter still in process of decomposition, still subject to further changes by decay, and for this very reason, destitute of any definite and determinate chemical composition and of any definite and constant physical and chemical characters.

The composition and properties of these humus bodies are, within narrow limits, dependent upon the particular stage of the decomposition, and upon the particular direction taken by the decay under the influence of varied external circumstances.*

All humus substances, from whatever source and by whatever process derived, have certain physical characters in common, among which the most important are the dark color, the great capacity for absorbing and retaining mois-

* Mayer, Agrikultur Chemie.

ture, together with all the mineral and other substances which that moisture may hold in solution. Another remarkable property of humus is its behavior towards the fine earth or clay resulting from the decay of rocks. Whenever these two substances in suspension in water, are brought together, their mutual attraction is so great that they form a most intimate mixture of grayish black color, which by gradual desiccation becomes a finely pulverized, always moist and friable soil, in which the humus may remain without further change for many years.

This mixture is the principle constituent of the so-called vegetable mould. (Senft, Gesteins- und Bodenkunde.)

Humus Acids.—The humus substances possess also certain chemical properties in common. While humus in itself is reckoned as an indifferent body, yet when in contact with certain bases, such as alkalies, lime, etc., it absorbs oxygen, and is thus converted into the so-called humus acids. The affinity for oxygen of these humus substances, when alkalies or similar bases are present, is so great that they are capable of taking it not only from the atmosphere, but also from the surrounding oxides, hence the strong reducing action exercised by decaying vegetation. The humus acids thus formed have the power of fixing and converting into insoluble forms, certain bases, especially the alkalies, in consequence of which the absorption of oxygen is still further increased, and a series of acids produced, each of which differs from its predecessor in having a larger proportion of oxygen and a smaller proportion of hydrogen and carbon; the last and end result of this oxydation being the production of carbonic acid and water. This uniformity in the behavior of the whole series of these otherwise different substances is another ground upon which the collective name of humus is to some extent justified. (Mayer, l. c.)

The acids produced by the decay of vegetable matter have, according to the experiments of Prof. A. A. Jullien, very decided solvent powers over many minerals, so that their influence in converting these minerals into soils, is even greater than that of the carbonic acid and other atmospheric agents.

The composition of these humus acids is still somewhat a matter of discussion, but the progress of the oxidation seems to take the following

course: The chemically indifferent humus is stimulated by the presence of alkalies to the absorption of oxygen by which it is converted into

1, Ulmic acid, and this further to
2, Humic acid, and this in turn to
3, Crenic acid, and this to
4, Apocrenic acid, and this lastly to
5, Carbonic acid,

So that the end result of the oxidation of all humus substances is the formation of a carbonate of an alkali or of an alkaline earth.

Each of these acids has its special characters, but their alkaline salts (especially ammonia salts) all have the common property of effecting either directly or indirectly, the solution of certain otherwise insoluble compounds existing in the soil. Thus the humate of ammonia, according to the experiments of Senft and others, is capable of dissolving silicates of alkalies and magnesia, phosphate of lime, sulphate of strontium, etc., which are comparatively insoluble even in the carbonated water of the atmosphere, which is so powerful a reagent in bringing about the decomposition of mineral masses.

In this way these organic acids of the soil become most important agents in effecting the decomposition of minerals, and in the conversion of some of their constituents into available plant food. (Senft, Gesteins- und Bodenkunde, p. 330.) The humus substances, by the oxidation of which the above named acids are produced, are called *ulmin* and *humin*, the former being characterized by a brown, and the latter by a black color.

The character of humus, as stated above, depends on the stage of the decay, and upon the conditions under which the decay takes place. Notwithstanding the difference in vegetable matter, it consists in all cases, of cellulose or woody fibre, and starch, or substances of similar composition containing carbon, hydrogen, and oxygen; of a small proportion of albuminous and other matters containing nitrogen in addition to the above, and lastly of incombustible mineral matter.

When decay goes on with full access of air, the carbon and hydrogen are oxidized to carbonic acid and water; but with limited access of air the carbon and hydrogen combine to some extent together, forming marsh gas, the nitrogen escapes partly as free nitrogen, partly in combination with hydrogen in the form of ammonia, and still another part remains in the humus as an ingredient of the acids above named. Mulder (Chemie der Acker-krume,) considers these acids as compounds of carbon, hydrogen, and oxygen alone, but Mayer and others believe that they all contain nitrogen as an essential constituent, or at least in some other form than

ammonia or nitric acid. As a matter of fact the larger proportion of the nitrogen in humus, is in a form very difficult of assimilation by plants, while a small proportion only is in the form of ammonia or nitric acid compounds.*

Lastly, when a mass of vegetation undergoes decay, under the pressure of a superincumbent mass of water or earth, by which access of air is cut off, it soon becomes impregnated with bituminous matter by which its further decay is prevented, and the humus substances thus become beds of peat or turf.

Humus, when incorporated with the soil, acts upon it in two ways; *physically*, by changing its properties, rendering it more porous, and a better absorber of heat and moisture; *chemically*, by introducing into it a source of ceaseless chemical activity, by which the soil constituents still capable of change are decomposed and the plant food which they contain rendered available, and by which a portion at least of the nitrogen of the humus itself, is converted into ammonia or nitric acid and thus turned to the service of succeeding generations of plants.

The humus of the soil, has in addition, the power of absorbing or rendering insoluble in the percolating waters of the soil, certain of the mineral and other matters which the roots of plants are capable of taking up. This subject will, however, be more fully considered in the next section.

Other Organic Agencies Concerned in the Production of Soils.

Our account of the formation of soil would be incomplete without some reference to the part borne by earth-worms. The significance of these animals as geological agents, was first clearly recognized by Darwin, 1837, and has recently formed the subject of a book by that illustrious author,† who has reached the conclusion, from a series of observations continued through many years, that all "the vegetable mould over the whole country has passed many times through, and will again pass many times through, the intestinal canals of worms." These animals excavate their burrows in the soil to the depth of three or four feet, sometimes even more. Their food consists of leaves and other

*Mayer calls attention to the great stores of nitrogen in peat and humus, which might be turned to account in agriculture, if a method could be devised by which it might be converted into an available form.

†The Formation of Vegetable Mould.

vegetable matter, which, after being digested and mixed with a great bulk of fine earth, which they swallow for the vegetable matter which it contains, or for the purpose of assisting in the digestion of their food, are brought up to the surface and ejected in their castings. The amount of fine vegetable mould which earth-worms bring thus from depths of three or four feet and spread upon the surface, is sufficient in some places to form an annual layer two-tenths of an inch in thickness over the whole surface. "There can be no doubt, that the materials of vegetable soil are largely commingled and fertilized by the earth-worm, and in particular that, by being brought up to the surface, the fine particles are exposed to meteoric influences—notably to wind and rain."*

It has not escaped the observation of many farmers in this State, that when a mass of sand has been washed down over a fertile bottom, it will, after a few years, again be covered by a layer of vegetable mould which earth-worms have, in the manner indicated, brought up from below and spread over it.

Judge Lawrence Johnson, of Mississippi, has also recently called attention to the part which earth-worms have borne in the formation of the vegetable mould of much of our prairie region; and there is no doubt that the importance of these agents in the formation of soils, will be more fully recognized in proportion as more careful observations are made.

Other burrowing animals, such as craw-fish, etc., undoubtedly play a similar, though less important, part in the production of soils.

Having thus traced the formation of soils from the crystalline and non-crystalline rocks, and shown in what way vegetable matter and animal life also contribute to its formation—having seen that every soil is a mixture in some proportion, of fragments resulting from the mechanical disintegration of rocks, of the fine earth produced by the chemical decay, of the dissolved matters extracted from the rocks during the process of this decomposition, and of humus or

*A. Geikie, Text Book of Geology, p. 454.

vegetable matter, we have next to treat of those physical and chemical properties of this mixture, which adapt it to give mechanical support to the roots of plants; to absorb and distribute the heat received from the sun, according to the needs of the plant; to imbibe and give out, when needed, the moisture received in the form of rain, dew, etc.; and finally, to act as a magazine of food, to be served out as the growing plants require it.

SECTION II.

THE SOIL IN ITS RELATIONS TO VEGETATION.

Every plant needs for the proper development of its different organs, a definite space in which to unfold its parts; a suitable substratum or ground into which its roots can penetrate, and thus secure it against the winds and other forces; in addition to these, a certain amount of warmth, air and moisture; and lastly, a supply of food in sufficient quantity and in an available form. For most of these things, a plant being confined to a single spot, is dependent upon the soil on which it grows.*

In how far and in what manner the soil responds to the demands thus made upon it, we shall endeavor to show.

Frame-work or Mechanical Basis of Soils; Constituents which Determine the Principal Physical Properties of Soils; Soil Varieties Depending on these.

The frame work of every arable soil consists of a mixture in variable proportions, of sand, clay, hydrated oxide of iron, lime, and humus or vegetable matter. Upon these constituents depend, in great measure, the physical properties of the soil, and their relative proportions in the soil, are often used as the basis of a soil-classification.

A general description, therefore, of each of these constituents and of the soil-varieties in which each predominates, may very well precede any account of the varying relations of the soil to plants.

*Senft, Gesteins- und Bodenkunde.

Sand.—Sand consists of fragments, flattened, rounded or angular, of rocks and minerals of various kinds, also of fossils, shells, etc. In the absence of clay or other admixtures, sand forms loose, incoherent masses, through which water percolates readily, and which is rapidly heated by the rays of the sun, and which, on the other hand, cools down rapidly by radiation at night. With a diminution in the size of the grains or individual fragments, the capacity for absorbing and retaining moisture increases, while the capacity for absorbing heat diminishes, so that a mass of very fine sand may approach clay in closeness of texture and heaviness.

When the individual fragments are larger than, for instance, a pea, the sand becomes gravel or pebbles.

In the composition of the separate grains, sands differ very widely. In Alabama by far the greater part of the sand grains are of quartz, but fragments of other minerals, and of rocks, may occur in every accumulation of sand.

Sands consisting solely of quartz grains, are essentially sterile, and become soils only upon the addition of clay or other matters, but where the grains are fragments of minerals or rocks capable of further alteration under the action of the atmospheric forces, these constitute a sort of reserve of plant food to be gradually converted into available forms. Under the action of the weather, therefore, these alterable sands may gradually become fertile soils.

Sandy Soils.—Sandy soils contain at least 85 to 90 per cent. of sand, (*i. e.*, small granular fragments of rock, no matter of what kind.)—Johnson.

They are light, *i. e.*, more or less loose or incoherent, dry and warm, *i. e.*, they are easily permeable by water, and readily heated. These qualities are of advantage in a moist season, but sandy soils are drouthy unless tempered with clay or humus. They are usually easily worked, and may be very fertile, holding the plant food in an available form. Unless, however, subject to periodical overflow, or otherwise supplied with plant food from without, such soils are rarely durable, especially if the grains are mostly quartz.

The case may occur where a siliceous soil becomes very heavy and impermeable, cold, and wet, even in the absence of much clay, by reason of the very finely powdered state of the siliceous matter. Such soils occur, only or chiefly, in the lower part of the State and are not very common. They have comparatively little retentive power for moisture or for manure, and are liable to suffer both from drouth and from excessive wet.

Clay.—Clay consists of exceedingly small earthy particles of uniform size and shape, exhibiting a strong attraction, not only for each other, but for water, and other substances. The purest of all clays is porcelain earth or kaolin, and it is at the same time one of the rarest. All the ordinary clays are the result of the admixtures of pure clayey matter with other substances, chiefly silica, or sand, iron, lime, carbonaceous matter, etc. That pure clays should be so rare, follows naturally from a property which distinguishes it among the soil-constituents, viz: that of absorbing and retaining or fixing within its substance not only water but everything that may be dissolved or held in suspension therein. Substances thus absorbed by the clay are no longer to be completely separated from it by mere washing in water, and appear, therefore, to be almost chemically combined.

The minerals by whose decomposition clay is formed contain, as a rule,

variable quantities of iron, lime, silica, etc., and as these are set free by the action of the weather, they are absorbed by the clay, constituting ferruginous clays, marl, loam, etc., which are not as a rule, to be formed by the simple stirring together of these materials. Yet, when an intimate mixture of clay, loam, or marl, in very finely divided state, is brought together with sand or carbonaceous matter, and thoroughly shaken up, as in the eddies of rivers, etc., these substances adhere together, forming, when deposited, beds of sandy loam and carbonaceous mud. (Senft.)

The coloring matters of clays are usually iron, humus, and manganese. Clays colored by iron are mostly either yellow, orange, or red, when the iron is in the state of the *per-oxide*, and blue or green, when in the state of the *prot-oxide*. The latter colors prevail where free access of air or oxygen is prevented, and where, by the agency of decaying organic matter, the per-oxide of iron is reduced to the protoxide. It is not unusual to find the surface of a clay colored red or yellow where exposed to the air, and blue or green below the surface.

All clays colored by iron become red by burning. Manganese frequently modifies the colors imparted to the clays by iron, and is usually the cause of the delicate pink, brown, or black tints sometimes observed. (Hilgard.)

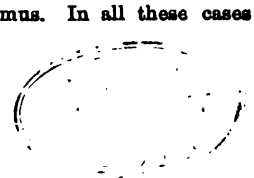
Clays colored by carbon or humus, are gray to black, occasionally bluish, but all such become white by burning, unless they contain also other coloring matters. In the region of the diluvial soils of Alabama, the drift deposits consist often of bands of clay interstratified with other beds. These clays are frequently remarkable for their bright colors. The clays, however, form a comparatively small proportion of the strata.

When moistened with water, a clay increases in volume, the pores become filled with water, and each particle of clay becomes itself moist. With further addition of water it may be reduced to a cream, and to a muddy fluid in which the clay remains long in suspension. With a moderate degree of moisture clays become tough, and more or less plastic, which qualities are lessened as the clay dries out. When dried it forms a mass often of almost stony hardness, shrinks and cracks, and is more or less impermeable by water. A mass of hardened, dry clay, when thrown into water, gradually absorbs moisture and crumbles down. When thoroughly impregnated with water it dries very slowly, because of the exclusion of air from its pores. Moist clay is very thoroughly pulverized by frost.

Clay, when wet, is always cold, because of the great quantity of heat absorbed in the evaporation of the included water.

Dry clay in lumps absorbs heat rapidly; when pulverized, however, rather slowly, but in either case retains the heat very well, provided the air is not moist.

In its relations to substances dissolved in water, lies the importance of clay as a constituent of soils. A moist, plastic mass of clay absorbs carbonate of lime from solutions in such a way that each small particle of the clay is combined with lime, from which it is not to be removed except with acids. This intimate mixture of clay with carbonate of lime forms the basis of marls. Towards carbonate of magnesia, phosphate of lime, and carbonate of iron, it shows a similar behavior. Gelatinous silica is in similar way absorbed and retained by clay to form the basis of loam, and a very similar relation is shown by it towards finely divided humus. In all these cases



the union is so intimate as to resist the action of ordinary solvents. (Senft, Gesteins- und Bodenkunde.)

The absorption and removal from circulation in the water of the soil, of the mineral elements of plant-food, are, as we have seen below, in many instances directly dependent upon the soil's content of clay, or of hydrated ferric oxide which, in many respects, closely resembles clay.

Clay Soils.—These are soils in which clay or finely pulverized, almost impalpable earthy matter predominates. They contain at least 60 per cent. of clay, mixed with sand, and usually also with a certain percentage of iron oxide and soluble silica. With 75 to 90 per cent. of clay and 10 to 25 per cent. of sand, a clay soil is heavy; with increasing proportions of sand, the clayey soil grades into clay loam, loam, sandy loam, and sand.

Clay soils are usually characterized by a fineness of texture and by great capacity for absorbing and retaining moisture. They, therefore, dry very slowly, but in drying shrink and are liable to crack open, exposing the roots of plants to the atmosphere, and also injuring them mechanically. (Hilgard.) When dry, such soils often become very hard and difficult to work, being at the same time almost impenetrable by the roots of the growing plant, and acquiring such a closeness of texture as to prevent the free access of the atmospheric air, without which no vegetable life is possible.

Clayey soils, unless broken up, absorb the rains falling upon them very slowly, but in wet seasons become thoroughly saturated with water, which fills all the pores, to the exclusion of the air, and when so saturated, clay soils, as above stated, dry with extreme slowness, thus remaining cold and wet, and favoring the reduction of iron, and the formation of the ferrous salts which are so injurious to all vegetation. With certain degrees of moisture, clay soils are tough and difficult of cultivation.

It is evident, from what has been said, that the first thing necessary in the improvement of a heavy clayey soil is the removal of the surplus water, and the breaking up and pulverizing of the material, which is effected by drainage, and by deep and frequent tillage. A mixture of sand is efficacious in the same direction; but this, in most cases, is not practicable without great expense. Where the mixing can be brought about by turning the course of a stream which washes down sand, it may often be profitably done.

The ploughing in of vegetable matter is also one of the best means of improving the physical properties of heavy soils.

Iron in Soils.—There are very few soils of any kind which do not contain enough of iron for the actual need as food of the plants growing upon them, and it is usually sufficiently abundant to modify very materially some of the physical properties of the soils. Its first effect is seen in the color imparted by it, which is usually some shade of yellow or red, and there are very few soils which do not have, in a greater or less degree, the colors due to iron. In the top soil, it is true, this color is often masked by the darker shade caused by vegetable matter, and, where the conditions are favorable to the reduction of the ferric oxide to the lower oxide, there is a corresponding change of color into blue or green. It will be shown below that the deportment of a soil with regard to heat, is in great measure determined by the color and the presence of iron; consequently, it increases the power of the soil to absorb and retain the sun's heat.

The hydrated oxide of iron shares with clay the property of absorbing and retaining moisture also, as well as the property of fixing in an insoluble form certain elements of plant food, so that in these respects the two substances are quite similar.

When distributed through the soil, the iron acts very much like clay, imparting a certain degree of toughness and tenacity, but unlike clay, when it accumulates to any extent, it forms a hard, compact, stony mass. In order that the iron may be taken into solution by the atmospheric carbonated water, it is necessary that the ferric oxide be reduced to the ferrous or protoxide state, which is usually effected by decaying organic matter. In solution, the iron may percolate through the soil, and sink till it reaches some impervious bed, like one of clay, for instance. Arrested thus in its course, the solution loses its carbonic acid, the iron absorbs more oxygen, and becomes again insoluble, and is deposited as a mass of brown iron ore, which may either be free from other admixtures, or, as is much oftener the case, it may be thoroughly mixed with sand or gravel, forming, as the whole mass solidifies, hard sandstone or puddingstone, such as are so often seen within the region of the occurrence of the Drift and Loam in the southern parts of this State. There is always this tendency to form a hard stony mass, but where the iron particles are separated by the other soil constituents, the actual induration is prevented. This is the case as a rule in the top soils, where vegetable matter is present; but in the subsoil, especially where underlaid with somewhat impervious materials, the formation of a hardpan is very common.

While the ferric salts, or compound of iron in the higher oxidized state, are of advantage to soils, the reverse is true of the compounds in which the lower or ferrous oxide (protoxide) take part. In the presence of decaying vegetable or animal matter, especially where free access of air is prevented, there is always a tendency towards the conversion of the higher into the lower oxide. This is shown to the eye by the change in color, from red or yellow to blue or green, and it happens always where water remains stagnant for any length of time. The blue mud which collects under such conditions is an evidence of the change described.

It is well known that none of our ordinary cultivated plants thrive in soils where these conditions prevail. This is not solely because of the formation of ferrous salts, but also because of exclusion of air from the roots of the plant.

The most obvious remedy for such a state of things is thorough drainage, by which the soil may be properly aerated.

Swampy soils of this kind are seldom at once productive, even after proper drainage, since a certain lapse of time is necessary to allow of the complete conversion of the lower into the higher oxide of iron, which follows upon the proper exposure to the air.

Defective drainage is attended with still other serious consequences. In porous well-drained lands, the various nutritive solutions are more or less uniformly distributed in soil and subsoil, but where a porous soil rests upon an imperious hardpan, there is a tendency towards the concentration of the iron below, as is so often seen in the formation of bog-ore, or black pebbles; while the soil, deprived of its coloring matter, becomes light-colored, gray, "crawfishy." The removal of iron from the soil in this way is further al-

most invariably accompanied by the removal of other materials of importance to the plants, especially of phosphoric acid in combination with the iron; vegetable matter or humus appears in similar way to be leached from soils under such circumstances.

It frequently happens that water which has been charged with iron in the manner described, appears in chalybeate springs. As the solution of the iron is made possible by the action of decaying vegetable matter, it follows that when this is removed, as, for instance, by clearing or cultivation, the chalybeate spring also disappears. Some chalybeate springs, however, depend not upon surface vegetable matter, but upon the deeper lying lignitic strata, and these will of course not be affected by the removal of surface vegetation. (Hilgard.)

Lime.—A certain small per centage of lime is found in every soil capable of supporting vegetation, and a certain minimum per centage is necessary to the life of plants.

In addition to this indispensable minimum, many soils contain considerable per centages of carbonates of lime in the form of perceptible grains, or impalpable powder. These, the calcareous or limy soils, are still further distinguished according to the predominance of the other soil-constituents, as calcareous clays, soils, calcareous loams, marls, etc.

The marls proper consist of clays intimately mixed with carbonate of lime in the state of a fine, almost impalpable powder, while the ordinary calcareous clayey soils may have the lime in distinct grains and larger fragments.

In a similar way, loamy soils may be calcareous or marly, in proportion as the lime carbonate is in distinct fragments or in impalpable powder.

It is quite customary in this state to give the name marl to accumulations containing the carbonate of lime in the form of shells, etc., irrespective of the matrix, whether sandy or clayey; but, properly speaking, a marl is a calcareous clay (and not a calcareous sand), with the clay and the lime in addition, so intimately united that even the finest particles contain both constituents. Clay soils are called calcareous when they contain as much as 2 to 3 per cent. of lime, and marly when they have as much as 10 per cent.

Calcareous soils, especially those which are more or less clayey, are rather stiff and difficult to work, but with moderate degree of moisture, are quite pulverulent, and usually more than ordinarily productive, because of the fact that the lime promotes the rapid decomposition of the vegetable matter present in the soil, and also renders available a certain amount of the nutritive ingredients of the soil.

A further account of the action of lime on soils will be found below in connection with the subject of manures.

Dr. Hilgard (Geology of Mississippi) has already called attention to the fact that the soils of the prairies, which are limy, have given rise to the supposition that all soils which resemble them, particularly in point of heaviness, are limy also. But the fact is that the tenacity and heaviness of clay soils are *diminished* by the presence of lime, as may be observed by comparing the "bald prairie" hill-tops with the level prairie with yellow clayey subsoil.

Lime, by rendering clay flocculent, diminishes its closeness, renders it more porous and easily drying.

Humus.—The mode of formation, and some of the more important characters of humus, have already been described, and in this place it is necessary to speak only of its great absorbent powers. On account of its retentiveness for water, it serves to improve the physical characters of sandy soils, and by its porosity, it may be used with advantage also to lighten heavy clay soils. As an absorbent of ammonia from the atmosphere, humus plays a most important part as a soil-constituent.

These properties are, to a certain extent, possessed by clay also, which may, therefore, in some degree replace humus in the soil, and there are in reality, as shown by Dr. Hilgard, certain clay soils which are quite fertile, and, at the same time, remarkably deficient in humus or vegetable mould.

Clay does not, however, possess these absorbing powers in so marked a degree as humus, and it lacks entirely the stimulating power of humus, which is due to the carbonic acid resulting from the decay of the vegetable matter.

One very important physical quality of humus is found in its color, which is dark brown to black. The absorption of heat by the soil is, as we shall see, far more dependent on its color than upon any of its other qualities, and the addition of humus to a clayey soil, besides making it lighter and more easily worked, greatly increases its capacity for absorbing and retaining heat.

1. The Soil as a Mechanical Support to Vegetation.

First, a soil must be of sufficient depth to give ample room for the roots to spread in every direction.

Shallow soils are not uncommon as the result of disintegration of rocks in place, especially upon summits; while along the slopes and at the bases of mountains or hilly districts, the depth increases, by reason of the washings. This state of things may be seen in many places in Alabama, in the region of occurrence of primitive or sedentary soils, *i. e.* in the northeastern quarter of the State.

In the drift-covered region on the other hand, the soils are usually sufficiently deep, except where partially removed by denudation, or where some impenetrable hard-pan or clay has the effect of preventing the roots from going downwards, and thus practically limiting the depth of the soil. The southern and southwestern parts of Alabama are generally covered with a great thickness of drifted materials, as has been pointed out above, and the soils are usually deep enough for the largest forest growth.

In the second place, the soil must be of such a texture as to be easily penetrable by the roots of plants, and this

texture will depend in great measure on the prevailing soil constituent.

When sand, or pulverulent limestone, or similar material predominates, the soil is loose and easily penetrable, but on the other hand does not possess sufficient tenacity to give proper security to the vegetation.

The other extreme is seen when clay is the prevailing material, for then, and especially when it is dry, the soil is almost impenetrable. Mixtures of clay and sand, or clay and vegetable matter, best fulfill the conditions required by plants.

2. The Soil as an Absorber and Moderator of the Sun's Heat.

Needs of Plants in Respect to Heat.—All plants need for their proper development a certain amount of heat. The sources of heat are the rays of the sun, the chemical processes going on the soil itself, and the internal heat of the earth. The amount of heat which a plant receives from the sun and from the atmosphere, is very variable, depending upon the season of the year, the hour of the day, and the amount of vapor of water at any time present in the atmosphere; and the atmosphere itself depends for its heat more upon the heat radiated from the earth, than upon that imparted directly through the rays of the sun. The roots of the plants moreover, receive their heat not directly from the sun, nor from the atmosphere, but from the soil. The soil, therefore, should possess the power of absorbing the heat furnished by the sun's rays, and of giving it up again to the plant when needed. It should also possess the power of yielding up to the surrounding atmosphere sufficient heat to prevent a lowering of the temperature below the limit within which the vital processes of the plant can be sustained.

Qualities of the Soil which determine its Temperature.—The amount of heat *received* by any given soil will depend on the climate of the region in which it occurs; on the inclination or slope of the field towards the horizon; on the point of the compass towards which it is turned; on the degree of protection against cold winds, etc., all of which are conditioned

by geographical position, topography, etc., which it is out of the power of man to modify. But the amount of heat *absorbed and retained*, will depend on the physical properties of the soil itself, and it is in the power of the farmer in many cases to modify these to his advantage.

The rays of the sun penetrate the soil only to a limited depth, beyond which the heat is transmitted by the conducting power of the soil.

The conducting powers of the rocks from which soils are derived, vary considerably, depending upon the chemical nature of the material and upon the closeness of texture. This conducting power, which is small at best, is, in soils, very slightly dependent on the nature of the material, since the solid particles of the soil are more or less separated by intervening air spaces; and since the air is a poor conductor of heat, it is not surprising that the heat from the sun should penetrate the soil with great slowness. Nothing illustrates this clearer than the fact that the temperature of the soil at a very slight depth from the surface is not sensibly affected by the changes in the seasons. In tropical regions this stratum of invariable temperature lies only a few feet below the surface, while in the higher latitudes, where the difference in temperature in the different seasons, is very pronounced, the stratum of invariable temperature lies deeper, being at most, about eighty feet below the surface.

The heat which falls upon a surface of rock or of soil, will be partly absorbed and partly reflected, and the amount thus absorbed or reflected, will depend not so much upon the nature of the material as upon the physical character of the surface. Thus a light colored, smooth, polished, and compact or close grained surface will reflect more heat and absorb less, than one which is dark colored, rough, and of loose texture. Soils differ from each other much less in regard to closeness of texture, coarseness of grain, etc., than in respect to their color, and thus the *color* becomes the chief factor which determines the soil's powers of absorption; a dark colored soil being one which absorbs more heat and reflects less, a light colored soil, on the contrary, being one which reflects more and absorbs less.

But the *degree* to which a soil will be heated by the sun's rays, will depend upon other things, viz., upon the specific heat or capacity for heat of the materials of the soil; upon the amount of heat which is lost in converting the water of the soil into vapor, and upon the conducting powers of the soil itself.

When different soils in a dry condition, are compared with each other, and with water, it is found that with equal amounts of heat received, the temperature of the majority of soils will, on an average, be raised four or five times as many degrees as that of an equal weight of water. Putting the specific heat (capacity for heat) of water at 1.00 the specific heats of soils will average from 0.20 to 0.25. Thus, while *dry* soils do not differ from each other very materially as regards their specific heats, the presence of water in the pores of the soils, will very essentially reduce their capacity for being warmed, and the universal use of the terms *cold and wet, warm and dry*, as applied to soils, sufficiently attests the general appreciation of this fact. A wet soil is of necessity a cold soil, for the reason that the included moisture requires a much larger proportion of the heat absorbed to increase its temperature, than is needed by the solid soil constituents.

And, besides, since the evaporation of water is attended with a loss of sensible heat a wet soil will be not only, on account of the great specific heat of water, more slowly warmed than a wet one, but will suffer an actual diminution of temperature from the heat lost or absorded in converting this water into vapor.

It needs only a moment's consideration to show that the temperature conditions of a soil are far more dependent on its content of water than upon its color.

With regard to the conductivity of soils for heat, it has been stated above that while the solid rock masses themselves, are poor conductors of heat, the loose soils which result from their disintegration are still worse conductors; the power of conducting heat diminishes with the porosity of a soil and increases with its compactness. Water is also a poor conductor of heat, and moist soils are hence probably not essentially different in this respect from dry ones.

However this may be, the capacity of a soil for absorbing and retaining heat, depends primarily upon its content of water, and its color, and in a less degree upon its porosity or compactness; upon the roughness or smoothness of its surface, and upon the nature of its constituent materials.

The foregoing remarks refer solely to the capacity of soils to *absorb* heat, but experiments prove that the rapidity with which soils cool down by radiation is in direct proportion to their powers of absorption; *provided*, the comparison is made with rays of the same temperature.

It might be inferred that soils which are most rapidly heated by the rays of the sun would on the other hand cool down most rapidly by radiation into space, but this is not always the case, for the soil absorbs mostly rays of *high* temperature, while it radiates those of *low* temperature. To illus-

trate, lampblack absorbs perfectly the rays of all temperatures, and on the other hand emits rays of all temperatures with equal facility. White lead, as might be supposed from its color, absorbs rays of high temperature very slightly, while rays of low temperature, such as those below 100 degrees, it both absorbs and radiates almost equally well with lampblack. A soil possessing the properties of white lead in respect to heat rays, would very imperfectly absorb the rays of the sun, which are chiefly rays of high temperature, while at night it would cool down very rapidly, since only rays of low temperature are then concerned.

Applications.—From the foregoing descriptions it may be gathered that dark colored, specifically light, and at the same time dry soils, are most rapidly heated when exposed to the sun's rays, and cool down most rapidly by radiation during the night, but since dark colored bodies absorb and radiate heat of low temperature more slowly than that of high temperature, the cooling would take place more slowly than the warming, and soils of this character would acquire and maintain the highest average temperature.

On the other hand, light colored, specifically heavy, and wet soils are more slowly warmed when exposed to the sun's rays, and also cool down slowest at night.

Such soils are, however, better protected by their light color against rapid heating by day, than against rapid cooling at night, and so their average temperature is lower than that of other soils. And besides, wet soils, by reason of loss of heat by the evaporation of water, have their temperature still further lowered. Hence soils with wet subsoil which are kept constantly wet and exposed to evaporation by capillary action, are of all soils the coldest. (Mayer, Agrikultur Chemie, II., p. 128.)

To apply these principles to the several chief soil varieties: *Sandy Soils*, when of dark colors, are most heated during the day, and cool down most at night, and in consequence, condense most dew; but sandy soils of light colors, are rapidly heated because of the coarseness of the grain, while they retain well the heat so absorbed, because of their color, and such soils condense comparatively little dew.

Calcareous Soils, well pulverized, when of dark color, are strongly heated during the day and retain their heat well at night, in consequence of their fine grained texture, and condense little dew; but when of light colors, are very slowly

heated by day and cool very slowly at night, and so also condense little dew.

Clayey Soils, when very dry and of dark colors, are strongly heated by day and retain their heat at night; when of light colors, are slowly heated by day, but retain their heat.

Clay Soils, when well moistened and of fine pulverulent texture, soon allow the moisture to evaporate and then become warm and remain so; but when of light color retain the enclosed moisture because they absorb less readily the heat necessary to its evaporation, and remain long cold.

Clay soils, thoroughly wet, and of the consistence of soft mud, are very slowly warmed, but once heated, remain warm; while those of light color, remain long cold and wet. (Senft, Gesteins- und Bodenkunde, p. 368.)

Relations between Subsoil and Top soil which affect the Temperature.—The subsoil exercises in many respects an important influence upon the overlying soil; it should possess such properties as would tend to *regulate* the temperature of the soil itself, and to this end, it should to a certain extent have properties the opposite of those of the soil. Thus, a very sandy soil which is easily and rapidly heated in the sun, and, on the other hand, rapidly cooled by radiation during the night, is kept uniformly and for a long time, warm and moist, by a subsoil containing much clay or humus. And similarly, a heavy clayey soil, inclined to be always cold and wet, is warmed, and the evaporation of its superfluous moisture favored by the possession of a sandy or calcareous subsoil.

A loose porous covering of stony fragments or of vegetable matters protects the soil both from the extreme heat of summer and the extreme cold of winter. (Senft, Gesteins- und Bodenkunde.)

And lastly, the depth of the soil greatly influences its temperature, for a shallow soil is exposed to both extremes of temperature, unless protected in the manner above named by its subsoil or its surface coating.

3.—The Soil as a Reservoir and Distributor of Water.

Demands made upon the Soil by the Plant in Respect to Moisture.

Water serves the Plant not only in being the solvent and means of translocation of its nutriment, but in connection with carbon it constitutes the substance of the greater part of vegetable matter; further, by imbibition of water the active parts of the plant are kept in a state of plasticity; and in solution in water, the useless products formed during the processes of assimilation are removed from the plant. Without water, no vegetation is possible. (Senft.)

If the plant could always receive at the proper time, from the atmospheric precipitates, the moisture which it required, the deportment of the soil towards the moisture falling upon it would be a matter of secondary moment.

As a matter of fact, a larger proportion of rain falls during the summer months when plants most need it, than during the winter, yet, because of the inequality in the distribution of this rainfall, no vegetation would be possible, unless the soil served as a reservoir from which the plant could draw its supply of moisture in time of need.

It is a historical fact, that with increase of population there is a corrsponding decrease of the supply of surface water, as is seen in the drying up of marshes, and the diminution of the quantity of water in the rivers and lakes.

This diminution is the inevitable sequence of increased cultivation; for not only are marshes and swamps drained off, but the supply of moisture to streams, &c., is decreased by the removal of forests, and by the enormous consumption of water by cultivated plants, and the retention of enormous quantities in the well tilled soil. Experiments made for the purpose of determining the amount of moisture exhaled by growing cultivated plants, have not led to any uniform results, for the reason that this amount is, to a certain extent, controlled by external conditions.

All those circumstances which influence the evaporation from a free surface of water, such as dryness or saturation of the atmosphere, hot, dry winds, etc., will in a similar way influence the exhalation of water by the growing plant,

and the experiments of Prof. Sachs have shown that plants exhale less water in proportion to the concentration of the fluid absorbed by their roots; in other words, *dissolved salts retard this exhalation.*

The evaporation through the leaves may be diminished, and even almost entirely suppressed, without serious injury to the plant, so long as the soil holds a sufficient supply of nutritive salts, for the plant itself is capable of exercising a certain amount of discrimination, and of adaptation to circumstances; for when the solution absorbed by the roots is concentrated, they assimilate relatively *more*, and when the solution is dilute, relatively *less* of the nutritive salts; that is, *they appropriate relatively more though absolutely less out of concentrated solutions than out of dilute ones.* It becomes thus possible for plants to endure protracted drouths when growing in fertile and well cultivated soils, *i. e.* such as contain concentrated solutions of the nutritive salts; while in poor soils in which the supply of plant food is scanty at best, they would perish.

Notwithstanding the variations in the estimates of the quantity of water exhaled by plants, it seems nevertheless well established, that the amount thus consumed by *cultivated plants* during their periods of active growth, is greater than that returned to the soil by rains during the same period; while not half of the water actually falling during this time, is really available to the plants.

It follows, therefore, that the growing crop must to some extent, depend for its needed supply of moisture, upon the soil, which has collected a part of the superfluous rainfall of the seasons preceding their periods of full development, to yield it up at the time when the moisture exhaled by the plants is in excess of that returned to the soil in the form of rainfall.

In contradistinction to cultivated plants, forest trees do not make use of the whole of the moisture furnished by atmospheric precipitates, the rest filters into the ground and serves to feed springs, brooks, and rivers. (Heinrich, Grundlage zur Beurtheilung der Ackerkrume, p. 109.)

That the enormous quantities of water thrown off by cultivated plants in the short period of their active growth, should be attended with rapid saturation of the atmosphere, and consequent violent rain storms, and electric disturbances, with flooded streams, and periods of drouth, is not to be wondered at. Forest trees exhale less moisture than

cultivated plants, their period of active growth are moreover much longer, and their action hence more equable.

We see from the foregoing statements, what the growing plant exacts from the soil, in respect to moisture. That the soil fully responds to these demands, the very existence of our cultivated fields demonstrates.

How the Soil Meets these Demands.

To serve as a reservoir of water for the use of plants, the soil must possess the power, not only of taking up or absorbing the moisture which falls upon it in the form of rain, and of condensing the water vapor from the atmosphere, but also of holding or retaining it in the stratum where the roots of the plant are developed, against all those forces which tend to draw it downward from the surface, or to bring it up and return it to the atmosphere in the form of vapor.

The deportment of the soil in these respects, while perhaps, to some extent due, as will be seen below, to the chemical nature of the several soil constituents, is in great measure dependent upon its physical structure; upon the size and shape of its individual particles; on their closeness of approximation and on the resulting size, shape, and number of the pores or interstices separating these particles. To this may be added also the degree of porosity of the separate soil constituents present in fragments of larger size.

Absorption or Condensation of Water Vapor.—Every solid possesses to some degree, dependent upon its chemical nature, the power of condensing gases upon its surface. This, as remarked by Johnson, is only an illustration of a principle of very wide application, viz: "The surfaces of liquid and solid matter attract the particles of other kinds of matter."

When this attraction or *adhesion* is exercised on gases it overcomes to a greater or less degree, their expansive tendency, and coerces them into a smaller space—condenses them. (How Crops Grow, p. 165.)

The condensation of vapor of water by the soil, being a

surface phenomenon, is greatly increased in amount by increasing the extent of the surface, that is, it depends upon the porosity of the soil. Experiments prove that humus excels all other constituents of the soil in absorbing power, and it is also one of the most porous of these constituents. Clay has greater absorbing powers than loam, and loam greater than quartz sand. But the absorbing powers of quartz sand is in great measure determined by the fineness of the grain, coarse sand having little or no absorbing powers, while mere mechanical subdivision or pulverization increases this absorption, in some instances, tenfold. The rapidity of absorption depends on the amount of vapor present in the air, while the amount absorbed depends on the temperature alone, according to the experiments of Knop.

The question has naturally arisen whether the moisture thus condensed by the soil, is of use to the plant; whether plants are capable of growing in a soil supplied with moisture solely by condensation from the atmosphere.

To answer this question, Sachs cultivated a number of different plants in different soils, under such conditions that the pot of soil and the roots of the plant were enclosed in a vessel in which the atmosphere was saturated or nearly saturated with moisture, while the leaves were exposed to the free air. Plants thus cultivated continued to live, and the previously wilted leaves not only recovered their turgidity, but remained fresh for two months; but the plants did not increase in weight.

Other plants cultivated under similar conditions, except that their roots instead of being in contact with soil, were simply suspended in air saturated with moisture, were unable to supply themselves in this way with the necessary moisture, and died. It would thus seem to be proven that the soil was capable of condensing from the atmosphere sufficient moisture for the needs of plants, and this conclusion is strengthened by the estimates made of the amount of water falling yearly as rain on a given area, as compared with the amounts evaporated from the same surface. These estimates show that the amount evaporated is in excess of that returned to the soil as rain, from which it would appear to follow that, unless the soil had the power of condensing and thus recovering a portion at least of this moisture, there would be a permanent loss.

Later experiments by Mayer, Heinrich and von Liebenberg, however, have thrown at least a shade of doubt over the conclusions of Sachs. In these experiments, various specimens of dry soils were exposed in some instances for a whole week, to an atmosphere saturated with moisture, and the amount of moisture absorbed determined. In little boxes containing these soils, plants were cultivated to a certain stage of growth, and then

under provisions for the least possible loss by evaporation through the leaves, water was withheld from the soils until the plants began to wilt. The amount of water still retained by the soil at this stage of the experiment was carefully determined, and in every case, it was found to be from one and a half to two times greater than that which the soil under most favorable circumstances was capable of condensing from a saturated atmosphere. From this it would appear to be demonstrated that plants are incapable of utilizing *directly* the hygroscopic moisture of the soil, and other interpretations have been given to the previous experiments of Sachs.

Mayer explains these experiments by suggesting that the moisture was condensed in the form of dew, for the production of which the unavoidable fluctuations of temperature in the apparatus afforded ample opportunity.

But whether or not the moisture condensed by the soil is directly available to plants there is very little doubt that the hygroscopic property of soil is *indirectly* of service, for as suggested by Heiden, the drying up of soils by evaporation from the surface, may be greatly retarded by this condensing power, and further, the temperatures acquired by soils when exposed to the sun's rays will be very materially influenced by the amount of hygroscopic moisture which they contain. "In a soil having, for instance, only 1.5 per cent. of hygroscopic moisture to evaporate, the food roots will be shrivelled up on a hot day, while in a soil having 12 per cent. they will remain uninjured." (Hilgard.)

Absorption or Imbibition of Water in the Liquid Form—Water Capacity.—If water be poured upon the surface of a dry sample of any kind of soil, it will penetrate the same leaving behind at every step adhering upon and between the solid soil particles, a certain percentage of moisture, and will sink to the bottom, only when the quantity of water remaining in the upper or surface portion of the soil sample is as great as the particular soil from its nature is capable of retaining, *i. e.*, when the surface portion is "saturated."

This water capacity or power of holding water, is *great* when the soil requires much water for its saturation, *small*, when the reverse is the case. (Lorenz, Grund und Boden.)

The amount of water which a given *weight* of any soil is capable of holding, varies between very wide limits.

Thus, according to Heinrich, (Grundlagen, p. 113), a coarse grained sand absorbed 26.5 per cent.; a sandy loam, 43.3; while a peaty soil absorbed 274.0 per cent.

If, instead of comparing *equal weights* of soils, we compare *equal volumes*, in respect to their absorptive capacity, the differences become much less striking; thus, a cubic foot of sandy soil absorbed 20.4 water; of a clay soil, 22.6; of a loam, 26.4; and of a peaty soil, 30.9; so that with the exception of the peaty soil, they all absorb approximately equal quantities. These results were all obtained by experiments on small quantities of the soils, of approximately cubical shape; but if long tubes are filled with the samples, and after their saturation with water, the *upper parts* of the soil columns be tested as to the quantity of water absorbed, the results are different. Thus near the bottom of the tube the sandy soil held 20.3 per cent. of water, the clay soil 50.7 per cent., while near the top of the tube of about three feet length, the sandy soil held only 8.6 per cent. while the clay held 37.6 per cent. It is seen from this experiment that while the sandy soil allowed the water to flow through it rapidly, the clay held it back with tenacity, and from comparison of the two sets of experiments it is no less evident that the amount of water which any given soil is capable of absorbing, will, in addition to the circumstances already enumerated, depend very materially upon the *depth of the soil stratum*, and a moment's reflection will show also that the water capacity of the surface will be, in great measure, also determined by the *character of its subsoil;* for instance, a sandy soil will have a very different capacity for absorbing water when it is underlaid with a clay subsoil, and when this subsoil is of pebbles.

CONDITIONS WHICH DETERMINE WATER CAPACITY.—The conditions which affect the capacity of the soil for absorbing and holding water, may be considered in turn.

(1.) *The character of the pores and the degrees of porosity of the soil.*—If a smooth or polished block of rock be partly immersed in water, a film of the liquid will be drawn up against its sides a small height above the general level of the water. If another fragment in similar position be brought near the first, the thin sheet of water between them will be lifted above the general water level, the higher in proportion as the two surfaces are brought nearer together. If instead of two we take several fragments and bring them together in such a way as to leave a little space or pore between them, the column of water thus enclosed will be lifted still higher. We have in this only an illustration of the fact that the adhesion of water to the surface of a solid is greater than the attraction of gravitation, and that in proportion as the extent of the surface of the solid is increased in comparison to the amount of the water acted on, so will the height be increased to which the water can be raised above the general level.

The greatest effects will therefore, within certain limits,

be produced when the enclosing surfaces are nearest together and the liquid film between them the thinnest.

If, for instance, we experiment with small tubes, it will be found that the water will be raised in them the higher as the bore of the tube is smaller, and since the effects are very marked with tubes of hair-like fineness, the action is usually spoken of as *capillary*. But while the height to which water may be raised becomes considerable only when the attracting surfaces are close together and the included water small in quantity, yet as we have seen, water is drawn up to some height against the sides of any solid which it is capable of wetting.

The application of these principles is evident. The soils may be considered as made up of a great number of solid fragments of irregular shape and various sizes. These fragments, when brought together, will touch each other only at points, leaving interestices or pores between, which, to all intents and purposes, will be small tubes, whose size and shape will depend on the fragments which they separate. If the fragments be large, and touch each other loosely, the interspaces will be large, if small and shaken well together, the contrary will be the case. The irregularity is still further increased when the particles differ in size, and smaller grains fill in the spaces between the larger. In addition, some of the particles may be solid and impermeable like glass or quartz, while others may be themselves porous.

The proportion therefore existing between the larger pores and the smaller or capillary one, the sizes of the pores, or what is the same thing, the fineness of division of the soil, and the character of the constituent particles, whether themselves porous or not, will determine the character of the soil as regards its power of absorbing and holding moisture applied to it in liquid form.

To illustrate this we may suppose three cases.

a. If the solid particles of the soil are of some material like quartz or an undecomposed silicate, and are moderately large or leave large pores between them, then if water be poured upon the mass, the greater part of it will run rapidly through the large interspaces following the law of gravity, and only a small part will adhere to the surfaces of the fragments. After the water has passed through, the pores will be empty as before, *i. e.*, they

will be filled with air, with the exception of the small quantity of water adhering to the surfaces.

b. If the pores or interspaces between the solid soil particles be very small, or *capillary*, the water will be drawn into them and will not descend further till all these capillary spaces are filled. In the first case the water is retained by simple adhesion to the surface of the pores, and since in the larger pores the surface is small as compared with its volume, the proportion of the water acted on by this surface attraction is small as compared with the whole volume acted on by the force of gravity, the greater part of the water, therefore, following the force of gravity, sinks through the soil. In the second case the surface of the pore is large in comparison with its volume, and as the surfaces are close together, the whole content of the pore will be within the sphere of action of the force of adhesion, and thus retained against gravity. In this way we may say that the capillary force is much greater than that of simple adhesion, though both result from the attraction between a liquid and the surface of a solid. In neither of the cases above given, has the water penetrated the solid particles themselves.

c. If the solid particles of the soil are themselves traversed by capillary pores, as is the case, for instance, with clay, these pores must also be filled before saturation takes place, and the greatest capacity for water in a soil will be found when the interspaces between the particles are of capillary size, and when, in addition, the particles themselves contain capillary pores. The capacity is less when the particles are porous, but the spaces between them are of larger size.

These illustrations taken from Lorenz,* show that the water-absorbing property of soil is chiefly a phenomenon of capillary action, and in very limited degree dependent upon simple adhesion. That this is true is shown by the experiment of Mayer, who found that quartz, when reduced to the finest powder, acquired a capacity for absorbing water greater than that of clay.

The larger non-capillary pores, while themselves retaining comparatively little moisture, furnish the channels through which percolating water rapidly comes in contact with the capillary pores by which it is absorbed. As the absorption by the capillaries is comparatively slow, it is evident that the size, shape, and number of the larger channels, their irregularities, and the resistances which they oppose from any cause to the free passage of water through them will very materially modify the soil's absorbing capacity.

In cases where the water, sinking through an open porous soil, is hindered from escaping by an impermeable substratum, these pores may become filled with water, and in

*Die Geologischen Verhaeltnisse von Grund und Boden.

this way a soil with comparatively small capacity for absorbing water, may at times hold a very large quantity, and become very wet.

2. *Depth of the Soil and Nature of the Subsoil.*—The experiments quoted above show that the moisture held in a long column of soil varies materially in the different parts of the column, and if a soil be of considerable depth, or have a porous subsoil, its capacity for absorbing moisture will depend chiefly upon the relative number of its capillary pores. But if the subsoil be at a shallow depth from the surface and comparatively impermeable, then the water arrested in its downward course will not only be soaked up from below by the capillary action, but will gradually rise and fill the larger pores also.

RETENTION OF MOISTURE BY THE SOIL.—The power of a soil to hold or retain the moisture which it has imbibed, is very closely connected with its absorbing power, and is measured by the resistance which it opposes to the escape of the water in any way, by sinking, by evaporation from the surface, or to any circulation or movement within the pores.

The chief source of loss of water in a soil is from its sinking through to lower levels, and according to the readiness with which water percolates them, soils are divided into permeable, loose, leachy, or drouthy and impermeable, close, or retentive.

The larger the pores of the soil, and the smaller the proportion of its capillary pores, the more rapidly does it allow the water to sink through it, and the more rapidly does it become dry after being wet from above; provided that the sinking of the water is not hindered by an impermeable subsoil.

On the other hand, the smaller the number of the larger pores, and the more numerous the capillaries, the greater the retentiveness. Soils with high capacity for absorbing moisture increase in volume with the water taken into the capillary tubes; the larger pores are thus made smaller, and the passage of water hindered. When, in addition, the soil particles are of different sizes, the smaller ones are often

washed or floated into the interstices of the larger, to the extent sometimes of filling them up entirely. In this way, a soil originally permeable may, by heavy rains, become almost impermeable. (Lorenz, Grund und Boden.)

Clay has the property of forming with water a plastic mass, which is almost absolutely impervious. The action of lime upon clay is to render it flocculent, and thus to diminish this tendency.

When water falls upon the soil from above, as in rain, etc., a portion of it runs off on the surface, especially if the quantity falling in a given time be very great; another part sinks rapidly through the lager pores, while a third part is gradually and slowly imbibed by the smaller or capillary pores. This absorption takes place either from the surface or from the water which fills the larger pores.

Falling upon a porous soil, with open subsoil, the water quickly sinks (except in so far as it is absorbed by the many pores which it traverses), and passes beyond the reach of the roots of plants. When an impervious stratum lies at short distance below the surface, the escape of the water in this way is prevented.

An impervious soil, on the other hand, absorbs water very slowly, forms a plastic mass, as it is called, which effectually resists the penetration of water, whether from above or below.

Fortunately, our soils are usually means between these two extremes, and the water which sinks through the upper to the lower layers, is partly, at least, again raised towards the surface by capillary action.

The height to which water may be raised by this force depends upon the fineness of the pores, and under most favorable circumstances is about five or six feet.

Whenever the constant level of the water is not more than this depth below the surface, moisture may by this means be permanently supplied to the root of plants. In a very porous soil, however, like one composed chiefly of sand, water can be raised in this way a much less height, and they are not likely to derive much benefit from this property.

The loss of water from the soil by evaporation depends

largely upon the temperature of the air and its relative dryness, but also in no small degree upon the nature of the soil itself.

Leachy soils are, at the same time, those that lose their moisture most rapidly by evaporation, while the impermeable soils, especially clay soils, retain the water most effectually against evaporation.

In this respect, humus is peculiar. It is tolerably permeable, but opposes more resistance than any other solid material to the evaporation of water, which it retains even at high temperatures very obstinately. If humus, therefore, be mixed with a permeable, easily drying soil, the mixture remains still quite permeable, but does not dry rapidly. (Lorenz.)

Distinction of Soils based upon their Deportment towards Water.

In respect to their behavior towards water, soils may be separated into two principal groups.* The first of these groups, in which *clay* predominates, unites in itself the qualities of closeness, high absorptive powers, great capillarity, great power of condensing moisture from atmospheric vapor, impermeability, and slowness in drying; in other words, these soils possess in an eminent degree all those qualities which favor the absorption and retention of water.

In contradistinction to these is the group of soils whose principal constituent is *sand*, which is permanent, or at least with difficulty decomposable, such as quartz sand. Such soils are loose, light, possess very slightly the power of absorbing moisture in liquid form, or of condensing it from the atmosphere; have few capillary pores, are leachy, and dry out easily. Between these two groups there are many gradations the result of mixtures, which possess in part the characters of each.

Besides the intermediate classes resulting from the mixtures of sand and clay, mixtures of other materials also bring about changes in the characters of the two chief groups above given. A clayey soil, for instance, becomes,

* Lorenz, Grund und Boden.

through admixture of lime, less close and stiff, more permeable, its absorptive power diminishes, and it dries more readily; in other words, it becomes more like a sandy soil.

Admixture of humus also makes a clayey soil lighter and looser.

A sandy soil becomes, by mixing with lime, more coherent; its absorptive powers and capillarity increase; it becomes somewhat less permeable; its other characters remain unchanged. Mixtures of humus make a sandy soil more coherent, impart to it greater absorptive powers and greater capillarity, and diminish its permeability and the rapidity with which it dries. Hence, a mixture of humus makes a sandy soil more like one in which clay predominates.*

Whether it will be advantageous to the plant for the soil to possess great absorptive powers or not, will depend very largely upon circumstances. In a rainy region, especially in a wet season, high capacity for moisture may be as detrimental as it may be beneficial under the opposite conditions. The evils of excessive moisture in a soil are the lowering of the general temperature, a too great dilution of the nutritive solutions, a filling of the pores of the soil with water and the consequent exclusion of oxygen, and the tendency which organic matter shows towards forming acid decomposition products when decaying in presence of too much water with limited access of air. (Mayer.)

While, by capillary action, water may be raised to some height, no circulation of water within the pores of the soil is possible without some cause which will bring about an inequality in its distribution in the different layers of the soil, since the effect of capillary action is to equalize this distribution. The drying of the surface by evaporation is usually the cause of this disturbance in the equilibrium in the one direction, while rains and other atmospheric precipitates destroy the equilibrium in the other direction.

When rain falls upon a soil in which the water is conducted with great slowness through the capillary pores, a very large proportion will be led off by surface channels

*Lorenz, Grund und Boden, p. 221.

without penetrating to any considerable depth, as may be seen in the circumstance that the dust of a road, after a heavy rain, is often completely dry a few inches below the surface.

On the other hand, when the surface is dried by evaporation, the moisture of a retentive soil is conducted from below very slowly, and such a soil will be able to resist a protracted drouth the longer in proportion to the hindrance which it opposes to the movements of the water within its pores. The slower the movements in this case, the better for the soil, whilst in order to profit by a rain, the more rapidly the water is absorbed and passes through the pores to the lower levels the better. The very same quality is thus seen to be both advantageous and detrimental. It is possible to provide, however, for the rapid and the slow conduction of water in one and the same soil, so that its behavior may be such as to secure the most from the rains falling upon it. This is done by loosening the surface, so that water falling upon it may penetrate rapidly because of the openness, or large size of the pores. When, on the other hand, by evaporation the loose surface becomes dry, the moisture, which is drawn up by capillary action, comes no further than this loose coating, which thus acts as a protection.

A covering of vegetable matter or of growing plants acts in a similar way to retard evaporation from the actual soil.

4—The Soil as a Magazine of Plant Food, and as a Regulator of its Consumption.

The Constituent Elements of Plants, and their Functions in the Vegetable Economy.

It has been ascertained by repeated experiments that eleven simple or elementary bodies are essential to the existence of all plants. These are carbon, hydrogen, oxygen, nitrogen, phosphorus, sulphur, chlorine, iron, magnesium, calcium, and potassium. If any single element of this list be wanting, or if it be supplied to the plant in unsuitable or unavailable form, the growth of the plant becomes impossible.

In addition to these, many plants contain also other elements which serve useful purposes in some cases, but which may be, and often are, dispensed with, without seriously interfering with the vital processes.

As to the parts played by each of these elements in the physiological processes of the plant, very much yet remains to be found out.

Of the non-metallic elements above enumerated, carbon, hydrogen, and oxygen are constituents of all vegetable cells, starch, cellulose, etc. Nitrogen and sulphur are essential constituents of all the albuminoid bodies which form a part of every growing plant cell.

Phosphorus, or rather phosphoric acid, seems, from the most recent experiments, to be in some way not yet clearly understood, necessary to the formation of the albuminoids.

These elements are, therefore, absolutely essential to the life of the plant.

Silicium is often deposited in the cells of certain plants, especially the cereals, giving to their stems a degree of rigidity and toughness, but experiments have proven that this element, while useful to very many plants, is not absolutely essential to any.

The same may be asserted of chlorine, which appears to be of advantage to many plants in favoring the translocation of starch granules, yet the fact that plants may be brought to full maturity when deprived of chlorine, shows that it is not absolutely essential. On the other hand, plants may easily be injured by an excess of this element.

Of the metals, potassium, calcium, magnesium, and iron, are universally present in the ashes of plants, and no plant can be brought to maturity when either of them is absent; yet comparatively little is known with certainty concerning the part played by each in the economy of the plant. Potash is known to be a constant accompanier of the carbohydrates, such as starch, cellulose, etc., and where these compounds are most abundant in the plant tissues, there will also be found the largest proportion of potash; but the real connection between the two is at present unknown. Iron appears to be essential to the proper development of

the chlorophyll grains, which form the green coloring matter of the leaves, &c.

Sodium, while present in the ashes of many plants, is not apparently essential to the growth of any.

Sources of these Elements.

Carbon.—This substance makes about half the dry weight of all vegetable tissues, and experiments have shown that it is taken by the plant from the carbonic acid which makes a variable but always small constituent of the atmospheric air.

All those processes by which carbon is oxidized, such as decomposition of organic matter, combustion, breathing of animals, etc., yield carbonic acid, and that it is present in the atmosphere in such small quantity, is to be ascribed not so much to a deficiency in the supply as to the greatness of the demand.

This gas is absorbed principally directly from the atmosphere by the green parts of the plant, but only when these are exposed to the light, the carbon is assimilated, forming an essential part of the vegetable cells, etc., while the oxygen is set free.

Plants are capable, also, of absorbing carbonic acid from solution by means of their roots, but not enough to sustain their life.

From all the analyses that have been made of the atmospheric air, it appears that the production of carbonic acid by the processes above named, keeps pace with its consumption by plants, so that the atmosphere may be looked upon as a practically inexhaustible source of this essential constituent of vegetable matter.

Hydrogen.—About a tenth of the weight of dry vegetable matter consists of this element, which the plant absorbs solely in the form of water, a compound of hydrogen and oxygen. The function of water, as above stated, is two-fold. It is absorbed by the plant, and in combination with carbon constitutes the *carbohydrates*, starch, cellulose, etc., which are essentially compounds of six atoms of carbon with six or more molecules of water. In these forms, water has lost its fluid condition, and appears as a solid. Secondly, water serves as a solvent and as a means of transport for the mineral nutriment contained in the soil, since this nutriment can be assimilated only after being brought into solution.

Water is taken up chiefly through the roots of the plant, yet a small proportion may also be imbibed by the stems and leaves, but plants soon wilt when moisture is supplied to them only through the parts above ground.

All, or nearly all, the moisture supplied to plants comes from the atmosphere, from which it is precipitated upon the soil in the form of rain, snow, etc. In some instances the moisture from the under subsoil may rise by capillary attraction to within reach of the roots of the plant, but the height to which water may be brought up by this force is comparatively small, a few feet at best.

The distribution of rain during the different seasons is very unequal, there being sometimes too much, sometimes too little for the well-being of plants. It is not within the power of man to change this, but it is in his

power to counteract, to some extent at least, the evil effects of this inequality, by deepening the layer of soil and thus increasing the capacity of the water reservoir.

Oxygen.—This element is a constituent of the carbonic acid and the water already spoken of, and is assimilated along with them, but in the conversion of these into vegetable matter, such as starch, woody fibre, etc., a part of the oxygen is set free. Plants, also, make use of oxygen for the purpose of converting a part of their organic tissues into carbonic acid, a process analogous to the breathing of animals. This process is most marked in the sprouting of seeds, and is attended with the liberation of a considerable amount of heat.

If from any cause the oxygen is excluded, e. g., because of stagnating water about the roots, or too close texture of the soil, the plant dies of suffocation.

The atmosphere contains an inexhaustible supply of oxygen.

Nitrogen.—It has for a long time been a matter of discussion whether or not plants have the power of assimilating the free or uncombined nitrogen of the atmosphere. The majority of chemists hold to the belief that only combined nitrogen is capable of being assimilated. Prof. Georges Ville is the chief champion of the opposite view, which rests mainly upon a phenomena presented by the growth of certain leguminous plants, and it is acknowledged that the source of a large amount of the nitrogen assimilated by these plants is still unexplained.

It is also, perhaps, an open question whether nitrogen may be assimilated in the form of *ammonia salts* as well as those of *nitric acid*, but there seems to be very little doubt that by far the greater part of the nitrogen of plants is absorbed by them in the form of nitrates. Experiments with a great variety of nitrogenous substances, such as urea, uric acid, blood, ammonia, etc., show that these become assimilable and therefore capable of serving as plant food, in proportion as they are converted into nitric acid.

Of the processes by which the free nitrogen of the atmosphere is brought into combination, (and they are not numerous), its oxidation to nitric acid by the agency of electric discharges, appears to be the one which furnishes by far the greater part of the combined nitrogen available to plants.

When once assimilated by plants and passed through them, into the bodies of animals, it enters into a variety of compounds. Upon the decay or combustion of these organic bodies, their contained nitrogen is converted into ammonia or nitric acid, according to the circumstances under which the decay takes place. (On this topic consult further, section III, "Nitrogenous Manures.")

Nitrification.—When organic nitrogenous matter undergoes decomposition in presence of strong bases (such as alkalies and lime), moisture, and a moderate degree of heat, they yield chiefly nitric acid. Under other circumstances, the principal product of decay is ammonia; but the ammonia of soils itself is in most cases ultimately converted into nitric acid. The value of a nitrogenous manure depends in great measure upon the rapidity with which its nitrogen is converted into nitric acid, and hence every circumstance which favors this oxidation, will be directly of advantage to the plant so manured. These conditions, as seen above, are thorough permea-

bility of the soil by the atmosphere, moderate moisture, high capacity for heat, presence of alkalies, &c.*

The above named products of decay may escape into the atmosphere, to be returned to the soil again by the falling rains and other precipitates, or they may be retained in the soil till taken up by another generation of plants.

We shall see below that while ammonia is in some cases rendered insoluble, and thus retained by the soil against the leaching effects of rains, yet such is not the case with nitrates, and since ammonia is peculiarly liable to be converted into nitric acid, the chances are numerous that a large proportion of the combined nitrogen which reaches the soil by any means, will be washed off into the sea before it can be assimilated by terrestrial plants. The readiness with which nitrogen is assimilated counteracts to some extent this tendency to waste, but the constant presence of nitrates in drainage waters, proves that a certain proportion of this important substance passes continually beyond the reach of vegetation, to which it is practically lost.

In the case of plants growing without cultivation, it is evident that the supply of assimilable nitrogen from the natural sources above mentioned, is sufficient for their wants; but cultivated plants make greater demands upon the soil in this respect, and not only so, but a portion of their assimilated nitrogen is annually removed in the harvests, and does not return to the field, like that contained in the falling leaves and other parts of forest trees, and other plants growing without cultivation.

When a strict comparison is made between the amount of nitrogen supplied annually from the atmosphere, and that removed in the crops from a given area, it can be shown that this supply is far from being sufficient for the wants of cultivated plants, and hence the farmer is under the necessity of adding, in the form of manure, the greater part of the nitrogen which his crops require.

In comparing together the above named organic elements of plant food, which, as we have seen, are all derived directly or indirectly from the atmosphere, there is this striking difference to be noted, that while Oxygen, Hydrogen, and Carbon are furnished by nature in the greatest profusion, the reverse is the case with Nitrogen, and the greater part of this element in an assimilable form, which ordinary crops need, must be supplied by the hand of man.

Phosphorus.—This element is appropriated by plants only in the form of phosphoric acid, or of phosphates of lime or the alkalies, and the only source of it is found in the phosphatic minerals of the rocks from whose decomposition the soils have been derived. The chief form in which it appears is a natural phosphate of lime called *apatite*, which is a comparatively insoluble mineral, and one difficult of decomposition.

These properties of phosphate of lime will explain the circumstance that a soil may often show, in chemical analysis, a comparatively large per centage of phosphoric acid, and yet the plants which it supports may suffer from

* The explanation of nitrification is still obscure. In some quarters it is thought to be due to the action of a specific ferment.

lack of phosphorus in an available form. In the decomposition of rocks, the natural phosphates which they contain may resist destruction, and hence be found associated with the coarser products, such as pebbles, sand, etc., resulting from that decay, rather than with the fine earth, which is the product of complete decomposition. In many rocks, the phosphoric acid may be present in very small quantity, but it is rarely entirely wanting when carefully looked for.

Sulphur.—This element is taken up by plants in the form of sulphate of lime, potash, soda, etc., in which condition it is pretty generally distributed, though often in mere traces.

The salts of sulphuric acid or sulphates are all more or less easily soluble, as compared with phosphates, and their presence may nearly always be shown in natural waters.

Notwithstanding the fact that plants need only small quantities of sulphuric acid, they often suffer for want of it, on account of the easy solubility of its salts, by virtue of which it is readily washed out of the soils. The favorable effect of an application of gypsum to the soil may often be explained by the presence of the sulphuric acid, and as sulphate of lime is a constituent of most superphosphates, it may in many cases be profitable to ascertain whether the good results obtained by application of these manures may not be, in a great measure, due to the comparatively cheap sulphate. (Heinrich.)

Chlorine.—This element occurs also in combination with potash, soda, magnesia, etc., and is generally distributed. Plants need only small quantities, and there is very little danger of their ever suffering from lack of it in any soil.

Iron.—Plants assimilate iron in combination with chlorine, sulphuric, nitric, phosphoric, or silicic acids.

In order that iron may not be injurious to plants, it must be present in the soil in the form of *ferric* compounds—*i. e.*, those of the highest oxide—because the salts of the lower or *ferrous* oxide are poisonous to all vegetable life. Soils usually contain a sufficiency of iron to supply the needs of vegetation. To prevent the formation of the injurious ferrous compounds, it is only necessary to provide for the thorough permeation of the soil by the atmospheric air.

Lime, Potassium, and Magnesium are all taken up in combination with some one of the acids above named, and they are present in most soils, though often in meagre quantities, and plants often suffer from lack of them. They are, therefore, often supplied to the soil by artificial means.

The Soil Constituents in their Relation to Vegetation.

All the inorganic or purely mineral substances which plants assimilate during their lifetime, and in decaying return again to the earth, must of necessity have been derived from the soil upon which they grew.

In a preceding section, we saw that the products yielded by the decomposition of rocks under the action of the atmospheric forces, were of two kinds: 1st. A number of

compounds of the nature of salts which were dissolved or extracted from the decaying rock by means of the carbonic acid and other constituents of the atmospheric waters. These make a very small proportion of the whole bulk of the soil, yet they play a most important part, since they are the *nutritive salts* or *plant-food*. 2d. A more or less insoluble remnant, which forms the great bulk of the soil, and which consists of two parts; a mass of fragments of variable size, either of the original rock or of some of its constituent minerals. These coarser particles have the general name of sand or gravel, and make the *framework* or *substratum* of the soil. The other part of the insoluble residue is a pulverulent earthy mass, which is the result of the decay of a great number of silicates containing alumina. It has the general name of clay, and makes the greater part of the "*fine earth*," as it is called. These two, sand and clay, framework and fine earth, from their chief function, which is to give mechanical support to the growing plant, are called the *mechanical constituents* of the soil. Upon them also, in a great measure, depend those physical qualities of the soil above described, by which it is enabled to store away and temper the sun's heat, and to absorb and regulate, according to the needs of plants, the moisture falling upon it.

On account of the differences in hardness, and in the degree in which they are acted on by carbonic acid and water, the various mineral ingredients of rocks, quartz, silicates, carbonate of lime, gypsum, etc., are, as we have seen, affected by weathering in very different degrees. The carbonates of lime and magnesia, and gypsum yield most easily and pass eventually entirely into solution. All the silicates are decomposed in time, the aluminous silicates giving as the result of their decay always some kind of clay; but quartz or silica withstands these agencies most effectually, being practically indestructible.

From this it will be seen that the coarser fragments produced in the crumbling of the rocks will be either, like quartz, capable of resisting any further action of the weather, and therefore permanent, or they will gradually undergo still further decomposition, the result of which will be, in the case of the aluminous silicates, the production of

some sort of clay and a number of soluble salts; in the case of limestone, and gypsum, ultimately a complete solution. Both of these kinds of gravel and sand, as the coarser fragments are called, serve as mechanical constituents of the soil, but with this important difference, that the decomposable fragments in decaying yield the soluble salts which form the mineral food of plants, and in addition to their office as mechanical constituents, constitute a sort of reserve of plant food to be drawn upon from time to time as chemical decomposition progresses. Upon the quantity and quality therefore of these decomposable mineral fragments which it contains, depend not only the soil's power of producing vegetation at all, but also the kind of vegetation which it is capable of nourishing at any time.*

And since vegetable matter in decaying adds to the soil all those elements which it had assimilated during the lifetime of the plant, humus and other organic detritus which form a part of every arable soil, may be classed, together with the undecomposed minerals, as forming the soil's reserve of plant food, or as *assimilable constituents in reserve.*

These share the passive functions of the mechanical constituents, but are also susceptible of contributing at any given moment to plant nutrition by the products resulting from their decomposition.†

These three orders of soil constituents, are thus shown in tabular form by Ville:

Soil.	Mechanical Constituents		Sand, Clay, Limestone, Gravel.
	Active Assimilable Constituents	Organic	Ammonia, Nitrates.
		Inorganic	Phosphoric Acid, Sulphuric Acid, Chlorine, Silicic Acid, Potash, Soda, Lime, Magnesia, Oxide of Iron, Oxide of Manganese.
	Assimilable Constituents in Reserve		Humus, Organic Detritus, Undecomposed Minerals.

*Senft, Gesteins- und Bodenkunde, p. 379.
†Ville, Artificial Manures, p. 168.

The majority of the substances above named as forming the *active assimilable constituents* of the soil, *i. e.*, plant food, are quite easily soluble in water, and it is evident that unless there were some means of preventing it, they would all certainly be washed out of the soil by rains and carried off to the sea. It has for a long time been known that when solutions containing salts of potash, phosphoric acid, ammonia, etc., are poured upon a soil, the water which filters through is to a great degree free from these substances.

In the same way, colored solutions are deprived of their color, and bodies giving off strong odors are completely deodorized when covered with a moderate thickness of soil.

This conversion by soils of soluble salts into insoluble ones, thus fixing or retaining them, has been called *absorption*, and it has been explained both as a physical or mechanical phenomenon, and as a chemical act.

It is of the greatest importance to the plant that as a rule, precisely those substances are absorbed by the soil, that serve as plant food, and the experiments which have been made for the purpose of determining the conditions which modify this absorption, the particular ingredients of the soil to which absorption is due, and the manner in which the absorption is effected, are very numerous. I shall endeavor in what follows to give some of the results of these investigations.

How the Soil Fixes or Retains the Soluble Nutritive Salts.

(1.) General Facts of Absorption.—If solutions be prepared containing the above named assimilable or nutritive substances, and be filtered through small quantities of soil, it will be found on examination of the fluid which drains through, that certain of them have been retained by the soil in larger proportion than others, but none of them have been completely absorbed. The salts of potash, ammonia, and lime, are usually very largely, those of magnesia and soda, very slightly absorbed by most soils. And of the acids, silicic and phosphoric have a tendency to form insoluble compounds, and they are hence most strongly and completely retained in the soil; while hydrochloric, sul-

phuric, and nitric acids are absorbed in extremely small quantities.

It will further be found that the filtered extract will differ from the original solution not only in containing less of certain ingredients, but also in having extracted from the soil certain compounds not present in the original solution; and in general, it may be asserted that for every equivalent of a base absorbed by the soil, a corresponding amount of some other base originally existing in the soil, will be liberated and thus pass into solution, while the acid element, if it be sulphuric, nitric, or chlorine, will pass through without absorption, and be found in the filtered extract. From these experiments it further appears that any base which has been absorbed by a soil, may be released from its combinations partly or entirely by some other base. (Johnson, How Crops Feed.)

If, now, the same experiments be tried with different soils, it will be found that they vary greatly in regard to their powers of absorbing different substances, and it is hence impossible to give any arrangement of the above named elements of plant food, which will show invariably the proportions in which they are absorbed by different soils.

As regards the quantity of these different substances absorbed by soils it depends—1st, Upon the particular compound presented to the soil; that is, on the substance with which the element in question is associated; 2nd, On the strength or concentration of the solution; and 3rd, On the absolute amount of the solution, that is, on the proportion between the quantity of the solution and the volume of the soil acted on by it.

1st. Experiments with potash salts have shown that the phosphate is absorbed in the proportion of 40 parts in 10,000, the carbonate in the proportion of 32 parts, the nitrate in the proportion of 25, the sulphate 21, and the chloride in the proportion of 20 parts in 10,000. The salts of ammonia show a slightly different deportment, but illustrate equally well the above statement. (Johnson, l. c.)

2nd. From a concentrated solution, absolutely more of a substance is regularly absorbed, than from a dilute solution, though a dilute solution gives up by absorption relatively a larger percentage of its content of nutritive salts than does a concentrated one, even where both are presented in the same quantity. The experiments of Peters, as quoted by Johnson, (How Crops Feed), illustrate this point sufficiently well. Thus, from a solu-

tion of potassium chloride of a degree of concentration represented by 1-80th, the soil absorbed 10 parts by weight in 10,000; this was, however, equal to *two-thirds* of the whole amount. From a solution of 1-20th concentration, there were absorbed 20 parts in 10,000, equivalent to *one-third* of the whole content; while from a solution of 1-5th concentration, the amount absorbed was 45 parts in 10,000, equal to only *one-fifth* of the entire content.

3rd. From a large quantity of a solution, more is absorbed, than from a smaller quantity, though both solutions be of the same degree of concentration. This follows from the fact that by removal of equal quantities of the absorbable substances, that solution which is in the largest quantity will be proportionally much less exhausted of its contents, than the other; will remain more concentrated; and we have seen in two, that from a concentrated solution more is absorbed than from a dilute one.

To these may be added a fourth statement, viz.: The fixation of these substances is neither complete nor permanent, for by means of large quantities of water they may be partially washed out of the soil again. The two preceding propositions follow naturally from this, which is only saying that the chemical compounds of which the absorbed substances form a part, are not wholly insoluble in water.

And not only so, but *saline solutions* have even stronger solvent powers over absorbed substances than pure water, as is shown by experiments which teach that any base that has been absorbed by the soil, may be released partly or entirely by any other.

On the other hand, it appears from numerous experiments that saturation of a soil with one base increases its absorbent powers for other bases; while treatment with acids, which remove absorbed bases, diminishes its absorbent power. (Johnson, How Crops Grow, p. 341.) Calcination diminishes, but does not entirely destroy, the absorptive power.

(2.) THE SOIL CONSTITUENTS UPON WHICH ABSORPTION DEPENDS, AND THE MEANS BY WHICH IT IS EFFECTED.—The explanations given by chemists of the cause of absorption, have vibrated between two principal views. The first experimenter in this field, whose work has received general acknowledgment, was Way, who considered absorption to be due solely to chemical action. On the other hand, Liebig held that a not inconsiderable part of the absorption was due to physical causes, analogous to the absorption of

gases by porous bodies such as charcoal. The later investigations have made it probable that the true cause of most of the phenomena of absorption is chemical action, though undoubtedly greatly modified by physical conditions; and that the fine-earth or clay, is the constituent of the soil upon which these phenomena depend. To present the subject in the clearest light, we shall consider in turn the composition of this fine-earth; the absorption of the several substances above named, together with the circumstances which most favor the absorption of each. In this direction, the researches of Prof. Knop, as detailed in his *Bonitirung der Ackererde*, are perhaps the fullest and most satisfactory. His investigations have shown that the fine-earth or pulverulent portion of all soils is a mixture of clay, of the products resulting from its decomposition, of absorbed substances, of incrusting substances, and of inert material in a state of fine division.

The clay being derived from the decomposition of very different minerals, may vary considerably in composition.

It contains almost invariably, silicates of iron along with the silicate of alumina. By the action of the atmospheric agents these silicates are gradually decomposed so as to give small quantities of hydrated ferric oxide, alumina hydrate, and soluble silicic acid. Finally, certain ingredients of the clay combine together to form hydrated double silicates containing alumina, which are of the nature of zeolites, so that the clayey portion of the soil may be looked on as a mixture of (1) the clayey substratum which forms the main mass of the fine-earth, (2) of hydrated ferric oxide and alumina, (3) of hydrous double silicates, and (4) of soluble silicic acid. The three last make up only a small proportion of the whole.

This mixture has in the highest degree the power of absorbing or rendering insoluble certain substances which are of the greatest importance to vegetation.

The substances which the clayey substratum has absorbed partly out of the original rock from which it was itself derived, partly from the fluids of the soil, partly from waters in which they were held in suspension, together

with the compounds resulting from the interaction of these on each other and upon the clay itself, are various compounds of

Carbonic acid,	Potash,
Silicic acid,	Soda,
Nitric acid,	Ammonia,
Hydrochloric acid,	Basic double salts of iron and alumina,
Phosphoric acid,	And lastly, organic or humus matter.
Sulphuric acid,	

The incrusting materials of the fine-earth, as defined by Knop, (Kreislauf des Stoffes, p. 486), consist of those substances which are dissolved in the carbonic acid of the atmospheric waters, and which become insoluble by the escape of the carbonic acid consequent on the evaporation of the water, and in addition those substances which require for their solution considerable quantities of water, and which therefore are precipitated upon concentration of the liquid dissolving them. The principal incrusting materials are the carbonates of lime and magnesia, and in small quantities, the carbonates of iron and manganese, and lastly gypsum and organic matter. The carbonates of iron and manganese are readily converted into the hydrates, which are in reality the incrusting materials. The loess and marly soils are formed from ordinary clayey soils by their incrustation with carbonate of lime. In many marls the carbonate of lime is in addition often merely mechanically mixed. When clay is thus incrusted by the carbonates of lime or magnesia, it loses its plastic properties and becomes loose and mild, an improvement often brought about artificially by application of lime to the field.

As inert constituents which are always present in soils, but of no essential importance to it, may be named—(1), quartz sand in exceedingly fine state of division; (2), carbonate of lime; (3), carbonate of magnesia and sometimes dolomite or magnesian limestone. This extremely finely pulverized quartz, approaching clay in its texture, is found in every soil of the framework of which quartz sand forms an essential part. The carbonate of lime appears as an inert constituent of the fine earth wherever the soil is derived from a limestone formation.

The soil undoubtedly possesses, like charcoal, the power of condensing within its pores certain gases, such as oxygen, ammonia, etc., and to this power is probably due the great oxidizing and antiseptic property of dry earth.

Like charcoal, soil has also the power of precipitating the coloring matter out of colored solutions, such as the fluid which drains from manure piles, and after filtering through soil these solutions are also in great measure deodorized. These phenomena of absorption are usually considered to be due to physical action.

The absorption of phosphoric acid, potash, and ammonia, cannot be altogether explained by physical action, and the investigations of Knop have led to the following results:

Absorption of Phosphoric Acid.—This acid is absorbed by the soil solely because it forms insoluble compounds with the bases existing in the soil. If a soluble salt of phosphoric acid, *e. g.*, a superphosphate, be applied to the soil as a manure, it will in a few days be converted into insoluble phosphates of lime and magnesia, and in small proportion also, phosphates of iron and alumina. The phosphate of lime itself gradually yields up its acid to the iron and alumina of the soil, and becomes thus still more inert. It is thus seen that of the soil ingredients, carbonate of lime and carbonate of magnesia directly absorb or render insoluble the phosphoric acid, and in addition, its absorption is favored by the presence in the soil of those silicates which by their decomposition yield ferric oxide and alumina. The alkaline phosphates are soluble in water. From the latest investigations as quoted by Knop, (Bonitirung), it is seen that the absorption of phosphoric acid is increased by all those means by which its combination with bases is favored, and from this it is concluded that the absorption of this acid is a purely *chemical process.*

Absorption of Potash.—The absorption of this base presents more difficulties. Knop's researches show that potash is absorbed—(1), in greatest quantity by a soil which contains a considerable amount of hydrous silicates, together with hydrated ferric oxide, and alumina hydrate; (2), by free amorphous silicic acid, and also by finely divided anhydrous silicates; (3), by the carbonate of ammonia and alumina, and by the phosphates of alumina and of ferric oxide.

It is not absorbed, or only sparingly—(1), by ferric hydrate or alumina alone; (2), by aluminates, *i. e.*, compounds of alumina with bases; (3), by the humic acid salts; (4), by the carbonates of lime and magnesia, and Knop believes that its absorption can be explained by simple chemical action, when it takes place from a solution of caustic potash or one in which the potash is combined with a weak acid such as carbonic; but its absorption by the soil when in combination with strong acids, such as sulphuric, hydrochloric, nitric, and phosphoric, he does not think capable of explanation by simple chemical affinity.

Absorption of Ammonia.—The absorption of ammonia is effected by the same materials that absorb potash, with two exceptions:

1st, Since ammonia forms, with phosphate of magnesia, an insoluble compound, this substance absorbs it, while it has no such effect upon the salts of potash; and 2nd, ammonia does not combine with silicic acid, whilst the amorphous silicic acid absorbs potash with avidity. Ammonia is slightly absorbed by acid silicates, containing no iron, and imperfectly decomposed; more completely by well decayed acid silicates; and most of all by thoroughly decomposed basic silicates, both hydrous and anhydrous. Ammonia is not absorbed by silicates in compact, glassy, or crystalline condition; nor by the carbonates of lime and magnesia; nor by gypsum; and in general it will be seen that the substances which absorb ammonia, are the same which are capable of forming with potsah also, insoluble double salts. The absorption of the two differs in this, that potash is absorbed by free silicic acid, by acid silicates, and by the phosphates of alumina and of iron, and not by the phosphate of magnesia, while ammonia is not absorbed by free silicic acid, very slightly by acid silicates, more by basic silicates, and still more by phosphate of magnesia.

So much as to the *materials* by which the absorption of these two bases is effected; as to the *cause*, opinions vary, but closer study of the phenomena of absorption have led back to the pretty general acceptance of the explanation originally offered by Way, which, as expressed by Mayer (Agrikultur Chemie), is as follows: "We find in the soil easily decomposable double silicates, the exact composition of which is unessential, which, along with alumina, always contain some other base, an alkali or an alkaline earth, or even several of these bases at the same time. These silicates have the property under certain conditions, of exchanging their accessory ingredients, (not the alumina). Thus, if lime is the principal accessory ingredient, as may be considered the case in the majority of calcareous soils, then the salts of potash and ammonia, and in a lesser degree those of soda and magnesia, react upon the silicate in such a way as to cause a double exchange of bases; the lime in combination with the acid of the applied solution, is extracted from the silicate and finds its way into the solution, while the potash, or ammonia, or soda, or magnesia takes the place of the lime in the silicate."

"From this presentation of the subject, it follows that the reverse reaction will take place, notwithstanding the difference in chemical affinity, whenever a solution of lime reacts upon the silicate formed by the reaction aboved detailed."

This explanation of the cause of absorption was based on experiments made with an artificially formed silicate containing silica, alumina, soda, and water, obtained by dissolving separately caustic soda, silica and alumina, and then mixing the solutions. A white precipitate was formed, having the composition aboved indicated. This artificially formed silicate had the power of absorbing bases from solutions containing them. On digesting this soda silicate of alumina, with any salt of lime, the lime replaced the soda and a lime silicate of alumina was formed. By digesting with a solution of potash salt, the soda was replaced by potash, and not only so, but upon digesting the newly formed silicate with a lime salt the reverse substitution could be effected, and the lime could be made to replace in turn the soda and the potash. The artificial silicate of Way had the composition of a *zeolite*, and it remained only to experiment with naturally occurring zeolites, which was done by Eichhorn, Mulder, and others, with *chabazite, natrolite, thomsonite, stilbite, prehnite*, &c., with the result of showing conclusively that the natural zeolitic minerals themselves are all more or less decomposed by saline solutions, i. e., that they all possess the power of exchanging a portion of their original content of lime or soda, for an equiv-

alent of potash or ammonia; in other words, of absorbing the latter bases, This property is not confined to the hydrous silicates, since when calcined. they still possessed it, though in much less degree.

From these experiments the inference was natural that the absorptive properties of the soil were due to the presence in it of compounds of the nature of zeolites, and consisting of silicates of alumina, together with silicates of calcium, magnesium, iron, and manganese, and that such is really the case, may be inferred from the fact, that when a soil is treated with an acid a portion of it is dissolved, which, while consisting principally of iron and alumina, contains also in small quantities, the other constituents of the soil, and while silica is only slightly dissolved in the acid, yet, after this treatment the soil is found to yield a considerable quantity of silica to a solution of carbonate of soda. This, according to Johnson (How Crops Feed) is the best evidence of the presence in the soil of easily decomposable silicates.

The action of these zeolites has often been compared to the hardening of cements. Thus, Mulder states that 100 parts of quick lime or calcium oxide, mixed with 11 parts of potassium silicate, finely powdered, make a good hydraulic cement, *i. e.*, one insoluble in water; and similarly with carbonate of lime and potassium silicate. And since all the materials for the formation of such cements exist in the soil, the question may naturally be asked why does it not always harden. This is because the cement is mixed with many times its own weight of humus and other indifferent bodies, and thus mechanically dispersed and kept apart. Carbonic acid and other solvents, and mechanical agitation are also unfavorable to the formation of solid masses. The reversion of soil into rock is, however, not uncommon in the subsoil, in which organic matter is less abundant, and where the materials are not stirred by the plow.

According to Mulder (Chemie der Ackerkrume), the chemical quintessence of a good soil consists in the zeolites in state of fine division disseminated through it and kept separated by solid organic or inorganic indifferent particles; and while the fertility of soil does not depend exclusively upon these zeolites, yet its chemical activity is altogether determined thereby, and to bring a soil in cultivation is equivalent to the production in it of these zeolites.

As regards their absorption by the soil, the difference between potash and soda, two otherwise similar bodies, is most remarkable, the former being retained by the soil in much greater quantity than the latter. This difference in the two may also be followed back to the original rocks in which they occur, where it is seen that the rocks containing soda are much more readily susceptible to the disintegrating action of the atmosphere than those containing potash, and the latter passes into solution in the atmospheric waters much more sparingly than the former.

In the above account it is seen that it is not only the elements of plant food that are absorbed by the soil, but also

occasionally certain other substances, and further, some even of the nutritive salts are not absorbed at all, or at most only very sparingly.

How the Soil gives back to Vegetation when needed, the Plant-Food which it has Absorbed.

(1.) COMPOSITION OF NATURAL WATERS, AND DRAINAGE WATER.—The waters of springs and brooks which flow over crystalline rock and over sandstones, take in solution seldom more than four or five parts of mineral salts in 100,000 parts of water. But when they flow over carbonate or sulphate of lime, *i. e.*, over limestone and gypsum they become much more concentrated or "harder." The concentration in brooks, rivers, and ponds is seldom greater than 2 to 2.5 to 1000. Well and drain-waters contain about four to five parts of solid matter in 1000, and when the land is saturated with salt the content may increase to 1 per cent.

Of the salts held in solution by ordinary potable waters, the chloride of sodium, and the carbonates of lime and magnesia, constitute the principal part, and if these three substances be subtracted, the remaining salts will not make up more than four to five parts in 100,000. From this it will be seen that the superficial portions of the earth's crust which have during thousands of years been washed out by atmospheric precipitates, no longer contain much that is still easily soluble, and th analysis of sea waters shows us where these soluble matters have gone.

Among the mineral salts which occur on the earth's surface, the chlorides are the most soluble; the sulphate of magnesia is also an exceedingly soluble salt, and these two together constitute the greater part of the solid matter contained in sea water. All sea waters have about the same composition, but differ principally in the degree of concentration. The solid matter of these waters consists, on an average, in 100 parts; of sodium chloride, 78.5; of chloride of magnesium, 9.4; of potassium chloride 1.0; of magnesium sulphate, 6.4; of calcium sulphate, 4-4; of magnesium bromide, 0.17; of calcium carbonate, 0,04; of silicic acid, and traces of ammonia and nitrates, 0.009.

All the salt or sodium chloride contained in the waters of the land and ocean, if spread upon the land would cover it to the depth of ten feet, which will give some idea of the quantity of solid matter leached out of the soil in previous times.

What the land loses now, is the small quantity of soluble mineral matters

set free by the decomposition of the rocks under the influence of the weather, and even a certain proportion of these, as has been shown above, are absorbed by the soil, and thus prevented from being dissolved and removed by percolating waters. A comparison of the composition of drain or well water with that of the ocean will be instructive, and to this end I give the analysis of a lysimeter* water made by Zoller, and quoted by Knop.

The lysimeter water in question contained in 100,000 parts :

Soda	2.17	Ferric oxide	3.56
Potash	1.18	Hydrochloric acid	1.73
Lime	75.73	Sulphuric "	14.36
Magnesia	12.52	Nitric "	55.69
		Silicic "	3.81

From this analysis it will be seen, that if the magnesia, lime and sulphuric acid (which last is combined with the lime as gypsum), be subtracted, there will remain only a very dilute solution, containing a minimum of potash, and mere traces, incapable of quantitative determination, of phosphoric acid and ammonia; the only nutritive ingredient present in any considerable quantity being nitric acid.

The reason why lime and magnesia together form the principal part of the dissolved solids of the water above noted, is because their carbonates, though insoluble in pure water, are exceedingly soluble in waters containing carbonic acid, which is the case with all natural waters. Potash is present in small quantity, and ammonia and phosphoric acid fail entirely, because all three of these substances are absorbed energetically by the soil, and thus removed from circulation. The oxide of iron comes into solution through the action of the humic acids which every soil fluid contains. The nitric acid and soda being absorbed in less degree, appear in the solution in considerable quantity.

(2.) DEPORTMENT OF THE ABSORBED SALTS TOWARDS VARYING QUANTITIES OF WATER.—Plants absorb their nutriment out of these very dilute solutions, and we have now to consider how the absorptive power of the soil is capable on the one hand, of preventing, on the drying up of the solutions, a degree of concentration which might be directly injurious to the plant, and on the other hand, in case of too much rain, a dilution of the fluid to the point at which the plant could no longer get from it sufficient nourishment.

This topic is clearly treated by Knop in his Bonitirung der Ackererde, from which the following account is taken:

*A lysimeter consists of a water-tight box divided by a perforated shelf into two compartments, an upper and a lower. This box is sunk into the ground to the level of the surface, and a layer of the soil, of the thickness of the soil in the field, placed upon the perforated shelf, and this soil is then cultivated and otherwise treated like that of the rest of the field. All the water which comes in contact with this particular portion of soil, will be collected in the lower compartment and may be examined from time to time.

If a solution of soil fluid having the composition of the lysimeter or drain water above given, be evaporated, the carbonic acid by which the lime and magnesia are held in solution passes off, and these bases, in proportion to the escaping carbonic acid, are precipitated out of the solution, and incrust the particles of fine earth.

Even if the lime were present in the form of sulphate, or gypsum, the solution could not become concentrated, since gypsum requires for its solution 400 to 500 parts of water, and when the concentration reached these limits, the gypsum would begin to crystallize out.

The carbonates of potash and soda, and all other salts of which these bases form a part, are soluble in water and would not therefore be precipitated out of the solution until it became excessively concentrated. But experiments in absorption have shown that in proportion as the solutions containing potash and soda salts, are concentrated, these bases are absorbed in larger and larger quantities, by the soil, and thus an undue concentration of the solution so far as they are concerned, is prevented. The iron, being under most favorable circumstances, only slightly soluble in the soil fluids, it follows that upon their concentration it will be for the most part precipitated in insoluble form and thus withdrawn from solution. From the above it will be seen that so far as the *bases* are concerned, the soil fluids cannot be so far concentrated as to become injurious to the roots of the growing plant, unless this concentration is effected by the presence in the soil of some other substance, such as hydrochloric acid.

If now, on the other hand, rain falls upon a soil which has been dried by evaporation till it contains only the moisture hygroscopically retained in its pores, this hygroscopic moisture is diluted, and soon become saturated with the carbonic acid present, and continually generated in the soil by the oxidation of humus.

This carbonic acid water redissolves the carbonates of lime and magnesia, precipitated by evaporation, and experiments show that pure water, and better still, carbonated water, is capable of dissolving always a certain proportion of the substances absorbed by the soil. In this way the soil fluid may again attain nearly the same composition that it had before its evaporation.

In regard to the acids, hydrochloric, sulphuric, and nitric, are retained by the soil in such small proportion as to be practically non-absorbable, and hence they are present in all soil fluids. Phosphoric acid is lacking in the soil fluid because the phosphates of lime and of magnesia are not soluble except in many thousand parts of pure water, though rather more soluble in carbonated water. It follows hence that the concentration of the soil fluid by evaporation cannot cause any considerable concentration of phosphates in the solution. The silicic acid which has been dissolved in water becomes insoluble upon evaporation of the water, and cannot thereafter be taken in solution either by pure or by carbonated water. And lastly, the humic acids become more and more insoluble in water in proportion as it becomes saturated with other salts, so that they also are precipitated on concentration.

Upon the evaporation of a soil fluid, the sulphuric acid will combine with the lime which is present in every fertile soil, because the alkalies disappear from solution on account of increased absorption due to increased concen-

tration, and the lime is the strongest base then left. But sulphate of lime is soluble only in 400 to 500 parts of water, and so, in any soil containing a sufficiency of lime, there is no danger of any undue concentration of sulphates. If, however, magnesia be more prevalent than the lime, there is the possibility that a solution of magnesian sulphate of injurious concentration may be formed, and experience has shown that all Dolomitic and Serpentine soils (magnesian) are more or less sterile.

We see, therefore, that upon concentration of the soil fluid the *acids* will all be precipitated out of the solution, the sulphuric acid in the form of gypsum, the silicic acid in its insoluble form, and the humic acids for the reason that their salts are all insoluble in solutions containing mineral salts, especially those of lime.

On the other hand, all these acids except silicic, are again taken in solution when the volume of the soil fluid is increased by rainfall. The silicic acid which may hereafter be found in solution must come from the gradual weathering of the silicates.

But in the case of hydrochloric and nitric acids, all the salts which they form with the bases occurring in the soil are soluble, and hence these acids are not absorbed, and chlorides and nitrates can therefore under certain conditions accumulate in the soil fluid upon its concentration by evaporation. If an undue accumulation of chloride of sodium, or common salt, should take place at any time, such a soil would be totally unfit for culture, and nothing but the so-called salt flora could flourish upon it.

Experiments with growing plants prove that their roots can exist in tolerably concentrated solutions of nitrates, and in fact the roots can take up even more of these salts than the plants can assimilate. And all plants can also take up certain quantities of common salt without injury.

Still the fact remains, that the soil fluid can become highly concentrated, so far as the *nitrates* and *chlorides* are concerned, but as we have seen, plants are able to endure a very considerable degree of concentration of nitrates. From what has been said above, it appears that of all the substances occurring in the soil, there is danger of undue or injurious concentration only of the salts of magnesia, and those of soda, and principally their chlorides.

(3). FURTHER RELATIONS BETWEEN THE ABSORPTIVE POWER OF SOILS AND VEGETATION.—(a) Plant food may be held by the soil in three forms, either in solution in the fluids of the soil, or disseminated through the soil in a state of fine powder, or lastly in a state of absorption. The rootlets of plants, by virtue of their own solvent action, are able to take up from the solid form a portion of their nutriment, *e. g.*, phosphoric acid; but for the greater part of its mineral food the plant is dependent upon the very small quantities of nutritive salts held in solution in the fluids of the soil.

As these salts are assimilated the fluid soon becomes exhausted of its contents, especially of potash, ammonia, and nitric acid, but acquires thereby greater solvent powers,

which are at once exercised upon the absorbed substances, with the result of speedily regaining almost its original concentration.

The action of the absorptive power of the soil becomes thus evident. Without it all those elements of plant food, set free in the weathering of rocks, would either be immediately washed away by the rains and thus lost entirely to vegetation, or in the most favorable case, accumulated in a comparatively concentrated form. They might thus become directly injurious to the plant roots, but in any case would very soon be entirely exhausted, and the plant made to depend for its supply of food solely upon the soluble salts furnished by the gradual decay of the rocks. But in consequence of absorption, these nutritive salts are retained in such a form as to render nearly impossible, the production of an injuriously concentrated solution, while on the other hand, this solution will remain very dilute, (in which form it is best suited to the needs of plants,) and at approximately the same strength, so long as any of the absorbed material remains in the soil.

This conservative action of the soil is best seen upon the application of manures. The soluble portion of the manure, so far as it is absorbable, is at once withdrawn from solution and brought into this insoluble condition. The soil fluid which, laden with all the soluble salts of the manure, would be in a state of concentration injurious to all plants, thus become diluted, but will remain for a long time of constant strength, because the absorbed materials, whenever the solution is diluted by the action of the plant roots or by the accession of additional water by rains, are gradually dissolved again and the normal strength regained. If on the other hand, the solution should become too concentrated by evaporation, a portion of its contents are absorbed anew and it becomes less concentrated.

The action of this absorptive property of the soil, is therefore to regulate the quantity of nutritive salts dissolved in the soil fluid, and its importance to the plant is evident.

From these considerations, it will be apparent why, upon a sandy soil in which there is a lack of those chemical compounds upon which absorption depends, a heavy manuring is often hurtful. Here, on account of the limited powers of absorption, an injurious concentration can easily occur, whilst with a heavy clay soil this would be an impossibility.

What has been said above applies to potash, lime, magnesia, and ammonia, which are regularly occurring constituents of every fertile soil, and also to phosphoric acid,

which, as we have seen, is very completely absorbed, or rendered insoluble to that degree that it rarely appears as an ingredient of the soil fluid. In this case the solvent powers of the rootlets themselves are brought into play.

In the case of sulphuric and nitric acids, as above stated, none of their compounds are absorbed to any considerable extent. Since all the salts of nitric acid are readily soluble in water this is plain enough, but not so with sulphuric acid. Although many of the compounds of this acid, with the constituents of the soil, as for instance with iron oxide, are quite insoluble, yet under ordinary conditions there is little opportunity for the formation of such insoluble sulphates. In the case of this acid, the relatively meagre absorption of its ordinarily occurring salts is of little consequence, since they are of little importance as plant food, but for the nitrates the contrary is true. On account of the great solubility of the nitrates, care must be taken as to the time of application of nitrogenous manures, lest they be washed away and thus lost to the plant. Notwithstanding the high degree in which ammonia is absorbed, yet on account of the ready and constant conversion of this substance into nitric acid, there is similar danger from loss. Still, since the roots of plants take up this form of nutriment as rapidly, and in nearly the same proportion, as it is produced by the decay of vegetable matter, the great solubility of the nitrates is not always the cause of the total loss to the plant. Where, however, the nitrates are applied in quantity as manure, a loss is scarcely to be avoided.

(b.) This absorptive power of the soil is also operative in retaining the useful materials in the top-soil, which is seen in the circumstance that a manure applied to any definite part of the soil, will during a whole season remain practically stationary, notwithstanding the tendency of percolating waters to disperse it.

(c.) And further, not only are most of the elements of plant-food retained in the soil by the absorptive power, but several of them are retained in an insoluble but at the same time extraordinarily available form. This is especially illustrated in the mode of absorption of phosphoric acid. When a soluble phosphate is applied to the soil, it is very soon, by chemical

reaction with certain constituents of the soil, precipitated in an insoluble form but in a very fine state of division, immeasurably more finely divided than it could be obtained by any mechanical process, and therefore much more uniformly distributed through the soil. The roots of plants growing in such a soil, while not encountering any phosphoric acid in solution, still have much more prospect of coming in contact with particles of the phosphate upon which the solvent powers of the rootlets may be exercised.

The significance of the absorptive quality of soils has been well summed up by Prof. Johnson, (How Crops Grow, p. 374), in the following words: "Disintegration and nitrification would lead to a waste of the resources of fertility, were it not for the conserving effects of those physical absorptions and chemical combinations and replacements which have been described. The two least abundant ash-ingredients, viz., potash and phosphoric acid, if liberated by the weathering of the soil in the form of phosphate of potash, would suffer speedy removal did not the soil itself fix them both in combinations which are at once so soluble that, while they best serve as plant food, they cannot ordinarily accumulate in quantities destructive to vegetation, and so insoluble that the rainfall cannot wash them off into the ocean."

"The salts that are abundant in springs, rivers, and seas, are naturally enough, those for which the soil has the least retention, viz., nitrates, carbonates, sulphates, and hydrochlorates of lime and soda."

"The constituents of these salts are either required by vegetation in but small quantities, as is the case with chlorine and soda, or they are generally speaking, abundant or abundantly formed in the soil, so that their removal does not immediately threaten the loss of productiveness. In fact, these more abundant matters aid in putting into circulation the scarcer and less soluble ingredients of the crops, in accordance with the general law established by the researches of Way, Eichhorn, and others, to the effect that any base brought into the soil in the form of a freely soluble salt, enters somewhat into nearly insoluble combinations, and liberates a corresponding quantity of other bases."

"The great and beneficent law regulating these absorp-

tions appears to admit of the following expression: *those bodies which are most rare and precious to the growing plant are by the soil converted into, and retained in, a condition not of absolute, but of relative insolubility, and are kept available to the plant by the continual circulation in the soil of the more abundant saline matters.*"

"The soil (speaking in the widest sense) is then not only the ultimate exhaustless source of mineral (fixed) food, but it is the storehouse and conservatory of this food, protecting its own resources from waste and from too rapid use, and converting the highly soluble matters of animal exuviæ as well as of artificial refuse (manures) into permanent supplies."

"By absorption as well as by nitrification the soil acts, therefore to prepare the food of the plant, and to present it in due kind and quantity."

SECTION III.

THE SOIL IN ITS RELATIONS TO ANIMAL LIFE.

PHYSICAL AND CHEMICAL CHANGES PRODUCED BY CULTIVATION; EXHAUSTION OF THE SOIL IN CERTAIN CONSTITUENTS OF PLANT-FOOD BY REMOVAL OF CROPS.

It has been shown above that when a plant completes its circle of life in one and the same spot, it returns to the soil, in its falling leaves and other parts, all the mineral and organic constituents which it had received therefrom.

Where the plant alone is concerned, there is the fullest restitution, and the conditions are present, not only for the maintenance, but for the actual increase of the fertility of the soil; since by the constant action of the weather, aided by the acids, etc., produced by the decay of one generation of plants, the inert constituents of the soil are gradually turned into an available form, and thus placed at the service of another generation.

But with the advent of animals, this equilibrium is no longer preserved, for the seeds and other tissues of the

plant are consumed by animals, and by them removed from their place of growth. And although in their droppings, and in their bodies after death, the total amount of mineral matter consumed in the plants on which they fed, is returned to the soil, yet the restoration is never to the locality from which derived.

By the systematic interposition of man, the natural provisions for the maintenance of the fertility of the soil, are still further disturbed; a portion of the vegetable matter growing upon a piece of cultivated soil is year by year removed in the form of harvests, and not only so, but by the removal of forests and the cultivation of annual plants, which, in a very limited space of time, require for their support vast quantities of water, the inequalities in the distribution of rainfall are very much exaggerated; heavy rain storms alternate with protracted drouths; the streams are at one time flooded, to be nearly dry at another; the soil, deprived of its protecting coat of vegetation, especially during the winter months, is exposed to all the destructive action of the rains, by which it is loosened, and in great measure carried away, to be deposited again in the valleys; and the hillsides, as well as the gentle slopes, are disfigured and often rendered unfit for cultivation by the cutting of gullies and ravines. With loose loamy soils, such as characterize the greater part of the State of Alabama, the destruction of lands from this cause probably far exceeds their exhaustion by the improvident systems of culture usually followed.*

To the traveler through the Southern States, the pictures of desolation presented so often around the older villages and towns, of red clay hills, gashed and scored by unsightly gullies, are all too familiar.

By the removal of the harvests, not only are the *mineral matters*, which serve as plant food, taken away, but the *vegetable matter* also, whose incorporation into the soil lends to it some of the most important of its physical characters; so that a field kept constantly in cultivation without returns,

*The great destruction of land for agricultural purposes by removal of forests, is well known in the older countries, and the imminence of the danger to parts of our own country from this cause is only too well shown in the late census returns.

will inevitably become sterile; but whether this result will follow after a few years' cultivation, or only after the lapse of many years, will depend on the original composition of the soil, and upon a variety of other causes.

That by the removal of crops from the field, *all* the constituents of the plant are at the same time withdrawn, needs hardly be said, but some of these constituents are supplied by the soil and by the atmosphere in such quantities that an exhaustion is not to be feared; while in the case of others a reduction in the amount below that required by the growing crop, is only a question of time.

Of the inorganic elements, Oxygen and Hydrogen are supplied by the atmosphere in practically inexhaustible quantity; the supply, however, of water, a compound of oxygen and hydrogen, which is so necessary to the welfare of the plant, is liable to great fluctuations, it being sometimes in excess of, sometimes below the requirements of the plant, so that the farmer is often forced, by suitable working of the soil, and by other means, not only to ward off the evils of excess, but also to store away this moisture, so that it can be utilized in time of need.

The supply of Carbon in the form of the carbonic acid of the atmosphere, is also practicably inexhaustible. The presence, however, of a source of this acid in the soil, by which the decomposition of its solid constituents is hastened, adds much to its resources, and hence a diminution of the organic matter may be attended both with reduction in the stock of mineral plant food in an available form, and with a deterioration in the physical properties of the soil.

The ultimate source of all the Nitrogen which enters into the composition of plants is the atmospheric air, and if plants were capable of assimilating this element in the free or uncombined state, the supply would be inexhaustible.

But in the opinion of the majority of chemists, plants have not this power, which is claimed at most only for a limited number. The natural sources of production of nitrogenous compounds are few in number and slow in action, and a thrifty growth of vegetation is possible only where the same nitrogen in combination is used over and over.

This is practically accomplished in the case of plants growing without cultivation, where the assimilated nitrogen of one generation is returned directly to the soil, and becomes available to the next generation.

But where a portion of the vegetable matter is constantly removed permanently from the field, as is done in the case of all ordinary crops, an exhaustion of the soil in respect to Nitrogen is inevitable, since experiments have demonstrated clearly that the quantity of this element removed in all ordinary crops is far in excess of that supplied to the soil from the natura[1] sources during the period of growth of the crop.

With regard to the inorganic elements or ash ingredients, the case is different. These are derived solely from the soil, and with every harvest a

portion of them is absolutely removed, and the soil in some degree impoverished.

The continued withdrawal of harvests without restitution in some form or other tends, therefore, inevitably to the exhaustion of the soil of all the inorganic elements assimilated by the crops.

The time required to exhaust the soil of any particular ash ingredient will depend on its original abundance in the soil, and upon the claims made upon it by the several crops.

Of these ash ingredients, *iron* is present in most soils in quantity far in excess of the demands of the plant, so that there is usually little to fear of an exhaustion in this respect.

Chlorine, *sulphuric acid* and *magnesia*, while present in small proportions in most soils, are also taken up by the plant in very small amounts, so that an insufficiency of these in the soil is scarcely to be feared.

In the case of *lime*, the same is true in great measure, and a deficiency in it is generally felt, after the soil has been exhausted, of other essential elements; and the good effects which follow upon the application of lime to fields are due less to action of the lime as direct food for the plant than to its beneficial action on the soil in other respects.

Phosphoric acid occurs in soils usually in very small proportions at best, while it is assimilated with great eagerness by the majority of plants. It is, therefore, of all the ash ingredients, the one most liable to be speedily exhausted. With regard to this substance, it is very well remarked by Mayer (Agrikultur Chemie, p. 166) that in order that a growing crop may not suffer for the want of it, it must be present in the soil in much larger quantity than is actually needed for the particular crop; for the phosphates of the soil are insoluble, and hence must be brought into direct contact with the root hairs before assimilation is possible; and since only a limited number of particles of soil can come in contact with the plant roots, only a small proportion of the phosphates actually present during one season of vegetation can be assimilated; and further, the quantity actually taken up will depend more upon the particular character of the roots of the growing crop than upon the amount of the phosphate present.

Potash is usually present in much larger proportion in soils than phosphoric acid, and is, on the other hand, assimilated in much larger quantity by plants. But while a soil may be temporarily deficient in potash, mere fallowing will often suffice to remedy this want, since a fresh supply of potash in available form will gradually be added to the soil in the decay of its decomposable rock or mineral constituents.

Next to phosphoric acid, however, potash is that ash ingredient which is soonest exhausted by continuous cropping without returns to the soil.

From the preceding, it is seen that *potash*, *phosphoric acid*, and *nitrogen* are the three elements of plant-food which are liable to exhaustion and which must hence be added to the soil from extraneous sources if its fertility is to be permanently kept up. The fourth element, *lime*, is also often added, not so much because it is not present in the soil in

sufficient quantity to serve the plant as food, but because of its favorable action on the other ingredients of the soil, in rendering them easy of assimilation; in promoting the rapid decay of vegetable matter, etc.

We have also seen that the removal of vegetable matter from the soil, aside from depriving it of a source of nitrogenous plant-food, and of the carbonic acid so important in promoting the further decay of mineral fragments, brings about a no less serious deterioration in its physical properties.

Means of Restoring the Fertility thus Lost.

In new countries where the land is cheap, after one field is exhausted, another may be taken into cultivation often at less cost than to keep up the fertility of the first, but the time comes in the history of every nation, when it is no longer profitable, or even possible, to follow this system, and the farmer is obliged to resort to some means of maintaining and increasing the fertility of his soil.

The means adopted to accomplish this end are varied, but they may all be arranged in two classes.

First.—Those *manipulations of the soil itself*, the object of which is to change in some way its physical properties to the advantage of the growing crop; or to render available some element or elements of plant-food already present in the soil, but in a form in which the plant is unable to make use of it; or to economize the stock of plant-food by using it up to the very best advantage.

The working of the soil with these objects in view, constitutes cultivation in its widest sense, which acts therefore either *directly* in a *mechanical* way or *indirectly, chemically* upon the quality of the soil, modifying the conditions of its fertility. (Hoffmann-Gohren, Agrikultur Chemie, I. p. 480.)

Second.—The quality of the soil may be changed by the *addition to it from extraneous sources*, of substances intended either immediately or in the future to increase its yield.

All materials used for the purpose are called *manures*, and they are *absolute* or *complete manures* when they contain all the elements of plant-food, especially the most important,

in sufficient quantity and in easily assimilable form, and are at the same time of such a nature as to react beneficially upon the physical properties of the soil.

They are *relative, partial,* or *stimulant manures,* when they contain only a part of the essential elements of plant-food, or their action on the soil is only partial or stimulating, or when their use depends chiefly upon this physical or stimulating action.

I. *Modifications of the Physical and Chemical Properties of the Soil without Additions to it from External Sources; Cultivation.*

The manipulations of the soil with a view to improve its physical and chemical qualities, may be included under the following heads:

1. Ordinary cultivation, plowing, etc.
2. Deep culture, subsoiling.
3. Drainage.
4. Fallowing.
5. Incorporation of vegetable matter.
   a. Remnants of crops, stubble, etc.
   b. Fresh plants; green manuring.

In addition to these, a system of cultivation is often followed which has the object of economizing the stock of plant-food possessed by the soil, and this is—

6. Rotation of crops.

The object of the first five of the operations named above, is to expose to the action of the carbonic acid and water of the atmospere, as great a surface of soil as possible, and it is effected in ordinary cultivation and in subsoiling, by stirring and breaking up the soil; in drainage, by setting the air in motion and thus increasing the surface of soil acted on; in fallowing, the element of *time* comes in to increase the effect of these agencies; and in the incorporation of vegetable matter, not only is a source of additional carbonic acid brought into the soil, but the plant-food of its deeper portions is brought up by the agency of the plant, and added to the surface.

That all these accomplish the same object as that attained

by ordinary cultivation with plow, hoe, etc., and are therefore equivalent to each other, has been shown by Liebig, whose statement of the subject is here given.

The mechanical working of the soil has for its object, first, the uniform mixing of those particles of the soil which have already given up nutriment to the preceding crop, and thus become to a certain extent exhausted, with other soil particles which have not been so exhausted; and second, to disseminate throughout the soil the elements of plant-food, and to convert them into forms in which they are assimilable by the next succeeding generation of plants. This is brought about by the chemical action of the atmosphere and water, and not by the plow, and hoe, which only assist in bringing together the air and soil particles.

To accomplish this chemical effect, it is necessary that the atmosphere should react upon the soil an appreciable length of time, and the more perfectly the soil is pulverized and the more frequently it is stirred by the plow, the greater will be the circulation of air in the pores, and the greater will be the extent of surface exposed to its action.

The produce of a field, however, does not increase in proportion to the amount of labor expended thereon, but in a diminishing ratio thereto.

This follows from the fact that fields differ in respect to the quantity of plant-food which they contain, and furthermore, even in those which have an abundance of such plant-food, its conversion into an assimilable form is not directly dependent on the work bestowed, but upon external agencies, which, like the atmosphere, are limited in respect to their content of oxygen and carbonic acid, the quantity of which would have to be increased in the same proportion with the work expended, if the latter is to be attended by proportional results. The increase in the produce of a field will be more nearly proportionate to the amount of labor expended on it, when the *time* during which the atmosphere acts on the soil is *lengthened*. Fallowing rests upon these natural relations between the atmosphere and water and the soil and its manipulation.

If by means of a given amount of labor the soil may be made to yield in the course of a year, a larger quantity of nutriment to the plants growing on it, than without such labor, and if it were in the power of the farmer to increase the action of the atmosphere upon his field in the same proportion as he increases his labor, the result would be an increased yield, which would, other things being equal, be proportional to the labor and the atmospheric action expended on the field.

The effect of drainage upon the increase in the productiveness of a field will thus be readily understood.

The stationary or circulating water of the soil, excludes the air from the deeper lying strata, and prevents its action upon the soil particles there. Drainage not only removes this water and renders the soil permeable by the air from above, but provides for something still more important, namely, a slow but continuous circulation of air in all parts of the soil lying above the drain.

And since, as remarked above, the cultivation of a field, besides a mixing of the soil constituents, has the object of bringing as much as possible, the soil and the atmosphere in contact with each other; and as the action of the

air upon the soil is greatly increased by means of a system of underground air passages, in consequence of which in a given time, a greater volume of air comes in contact with the soil particles, it follows that a well drained field will be restored to a condition favorable to the growth of plants in shorter time than will a field without drainage. The plow sets the soil particles in motion and thus increases the points of contact between soil and air; drainage promotes a circulation of air, and thus also increases these points of contact; so that the mechanical acts of cultivation and drainage both bring about the same result in the end, they both increase the action of the atmosphere upon the soil. A well drained field, with an equal amount of working and under otherwise similar circumstances, yields a larger amount of plant-food to the crop growing upon it than an undrained one.

The incorporation into the soil of the vegetable matter which it has itself produced, either in the form of stubble, green crops, or of stable manure derived from the crops, in reality accomplishes practically the same result.

By the decomposition of this organic matter, there is a continual formation in the soil of carbonic acid, which plays a most important part in effecting the decomposition of rock fragments, and the solution, and dissemination of the plant-food within the soil, thus augmenting and accelerating the action of the plow and the atmosphere.

In addition to this, the forage plants by means of their deeply penetrating, widely branching roots, take up the nutriment disseminated in the subsoil. A greater part of this plant-food is accumulated in the stems, leaves, etc., which, returned to the top soil in the form of manure, increase its content of assimilable plant-food. By this means the top soil is enriched at the cost of the subsoil.*

So much for the general relations existing between the various manipulations to which the soil is subjected in the interest of the growing crop. Some of the special ends to be attained by means of each deserve further notice.

1. ORDINARY CULTIVATION.—The objects to be accomplished by this work have already been sufficiently noticed, for our purposes.

2. DEEP CULTURE; SUBSOILING.—The object of deep culture is to increase the volume of the magazine from which the plant may draw its food. By loosening the subsoil the atmospheric agencies have access to the deeper lying soil strata, where they effect the decomposition of the mineral matters and their conversion into available plant food. At the same time the roots are enabled to penetrate deeper and thus to collect their nutriment from a greater volume of earth. The plant will thus be better provided with nourish-

*Liebig, Die Chemie in ihrer Anwendung auf Agrikultur, etc. p. 79 & f.

ment and will consequently be more flourishing, and the result will be a more remunerative crop.

A deeply cultivated soil has in other respects, a great advantage over one with shallow tillage, for not only does it yield better crops, but the plants being more vigorous and better nourished, are better able to withstand frosts, drouth, and wet seasons. The increase in the depth of the soil allows it on the one hand to absorb more moisture, and on the other provides for the removal of an injurious excess of the same.

The growth of certain deep rooted plants is moreover rendered possible only with a sufficient depth of soil.

Such are some of the advantages of increased depth of soil, desirable in all cases except where deep plowing would break through a retentive stratum into beds of loose pebbles, which would cause excessive drainage and a loss of fertility. These advantages are always secured when the subsoil is merely loosened and stirred without being brought up and mixed with the top soil.

Whether the subsoil may with advantage be mixed with the soil, will depend upon the relative character of the two, and upon a variety of circumstances which must be carefully considered, since great losses may follow from injudicious mixing of soil and subsoil.

The advantages to be secured by a mixing of subsoil with top soil are twofold, physical and chemical.

Thus a light sandy soil might be greatly improved in its physical qualities by an admixture with a heavier clayey subsoil. This relation of soil and subsoil is not uncommon in this State. On the other hand, a heavy top soil would be improved by mixing with a lighter sandy subsoil. This latter case is far less common than the preceding.

If the subsoil is richer in the elements of plant food, either naturally or in consequence of cultivation, mixing it with the top soil will be of advantage to the latter, because it will be equivalent to adding to the soil a certain quantity of plant food. (Hilgard.)

Whether the subsoil is richer or poorer than the soil in the elements of plant food, can only be told by analysis, or by actual experiment. But whatever may be the relations of soil and subsoil in this respect, it is necessary to remember that the plant food present in the subsoil, in so far as the latter has been less exposed to the action of the atmosphere than the soil, is in a form in which it is not easy of assimilation by the plant, and the mixing of the subsoil with the soil may for a time have the effect of diluting the latter with so much dead or inert matter, and decreasing its productiveness. This may be avoided by first merely loosening the subsoil without bringing it up, and allowing it to remain thus exposed to atmospheric agencies for some time before actually mixing with the top soil. Many subsoil plows are constructed with this end in view. If the subsoil be actually mixed with the soil, the conversion of the plant food into available form may be hastened by incorporating vegetable matter, or by the use of lime or other stimulant manures. It must always be borne in mind, that an increase in the depth of the soil stratum by subsoiling involves a corresponding increase in the quantity of manure to be used.

If the absolute amount of plant food in soil and subsoil is the same, then,

as Dr. Hilgard has remarked, subsoiling means little else than deep plowing, but if the subsoil be poorer than the top soil, then it will be a disadvantage to mix it with the latter, which it would merely serve to dilute.

In most cases a mixing of subsoil with soil is attended with a more or less decided change in the physical characters of the latter, and it is not always possible to say whether this change will be of advantage or not. "For," as remarked by Dr. Hilgard, "while on the one hand we may derive from it a double advantage if it should happen both to correct the physical condition of our soil, and to add to its stock of fertility; it may on the other hand utterly and irrecoverably ruin our land if the change produced with respect to lightness or heaviness, should happen to fall in the wrong direction. In this case even the greater native fertility of the subsoil would be of little use. Whenever a soil possesses the proper physical constitution, however poor naturally, it is susceptible of improvement at least, and thus far valuable.

But if its physical properties be extremes on either side (whether naturally, or on account of injudicious subsoiling), the soil will always be an unsafe one, no matter how great its stock of nutritive elements, and whether native or superadded in the shape of manures."*

With a subsoil of proper constitution, a soil even though light and sandy, is still capable of improvement, but if the subsoil be porous and leachy, it will allow the nutritive ingredients to sink below the reach of plants and thus be lost, and these things must be considered in connection with any proposed system of subsoiling.

A very heavy and impervious subsoil may be quite as injurious in its effects as a light one; but the defects of the former may to some extent be remedied by thorough drainage, while those of the latter are often very difficult to deal with. (Hilgard.)

3. DRAINAGE.—The water that falls in the form of atmospheric precipitates upon the land, partly flows off on the surface in rills, brooks, and other streams, by which it is carried to the sea; or partly soaks into the ground to make its appearance at some lower level as a spring; or partly reaches the sea wholly by underground passages. The rivers and other streams may therefore be considered as the natural channels of surface drainage, while springs are the natural outlets of underground drainage. But natural drainage, from a variety of causes, is seldom uniform and perfect over large areas, and the ridding of the soil of its superfluous moisture, is a very common preliminary to the taking into cultivation of many valuable tracts of land. For however great may be the natural fertility of a soil, an excess of moisture will effectually prevent the growth of all ordinary cultivated plants.

*Geology of Mississippi, p. 247.

The ready escape of surface waters, is provided for by deepening or straightening the channels of the streams which effect the natural drainage, or by making extra channels in the shape of water-furrows, ditches, and canals.

The soil and subsoil are freed from stagnant water by means of artificial underground channels.

The first named mode of draining is very commonly practiced, but the construction of underground drains being very costly, belongs rather to the older countries where land is dear, than to the new.

A soil cannot be said to be properly drained unless the permanent level of the water in it is far enough below the surface to permit the proper development of the plant roots. This minimum depth is usually given at three to four feet.

The advantages of drainage are due to two causes, to the removal of surface waters or the lowering of the permanent water level in soil and subsoil; and to the penetration and circulation of air in the soil, which the removal of the water permits.

Wet land produces only inferior grasses, which are both late in coming to maturity and liable to fail early.

Such lands are always more difficult to cultivate, because of their toughness; farming operations are liable to be interrupted by rains, and the times are limited during which plowing can be done at all, and lastly, more plowings are necessary, than on dry lands. The seeds are moreover liable to mould and rot in wet soils, and the decay of organic matter under such circumstances causes the production of noxious substances, which are not only poisonous to the plant, but are also thought to be productive of disease. With proper drainage, the soil becomes more easily tilled, farming operations are less liable to interruption, the injurious substances which naturally collect in an undrained soil are washed out, or prevented from forming at all, the seeds germinate in due time, and the crop is less likely to be cut short by unfavorable seasons, while the great "improvement in the general health of the districts where drainage (and particularly underdraining) has become general, is not among the least noticeable advantages which have followed its introduction in many cases." (Hilgard.)

In well drained land, the rain water, instead of running off on the surface and washing away the most fertile portions of the soils and manures, filters through the soil, allowing it to absorb and retain all those nutritive materials which may have been taken into solution. In a region where the lightness of the soil exposes it to great injury from washing, the advantages of proper drainage can not be over estimated.

Excess of moisture in a soil keeps down its temperature, and renders it cold. When this excess has to be removed by evaporation, a vast amount of heat must be thus expended before the sun's rays can warm the soil at all. The water in a soil being a good radiator, carries off a large amount of heat in this way. Wet soils are moreover very slowly warmed by the sun, be-

cause the stagnant water conveys no heat downwards, and the heated water being lightest, remains at the surface. But when cooled by radiation, the cold stratum sinks, while the warmer water from below rises to take its place, and thus, by a constant circulation, the temperature is rapidly lowered to the point of maximum density, about 40 degrees Fahrenheit. A slight lowering of the temperature below this will cause the formation of ice. Thus, in various ways, stagnant water in the soil keeps its temperature constantly lower than that of a well drained soil. And further, where the rain water is permitted to filter through the soil without hindrance, it carries down with it the heat which it has acquired from the atmosphere and from the surface soil, giving it up to the subsoil. Drainage thus corrects the coldness of soils, renders them dryer and warmer; in drained soils, seeds may be sown often ten to fourteen days earlier; crops come to maturity earlier, and may grow without liability to injury from frosts many days later. Thorough drainage may, therefore, sometimes be equivalent to producing a change and improvement in the climate. (Johnston, Agricultural Chemistry.)

And not less important are the advantages due to the fact that as the rain water sinks through the soil, it drives out the air already in the soil, and draws after it a fresh supply, thus establishing a kind of circulation of air in the soil.

The importance of a supply of oxygen to the roots of plants has already been spoken of. The water of the soil holds in solution a certain amount of oxygen, which is sufficient for the needs of plants, except where it is stagnant and the dissolved oxygen is removed by decaying vegetation.

The roots will not penetrate where they can not get a supply of this necessary element, and defective drainage acts like shallow tillage, in confining the roots of plants to the uppermost strata of the soil, where they are exposed to all the changes of temperature, etc., and are besides compelled to seek their nourishment within narrower limits.

Access of air to the soil is moreover needed to convert the insoluble constituents of the same into forms in which they are available to the plant as food, and a lowering of the water level increases the quantity of soil acted on by the disintegrating agencies of the atmosphere, and has thus the effect of deepening the soil, or of deepening the stratum within which the plant may find its nourishment.

The deeper the roots penetrate, the greater will be the supply of nourishment available to the plant, and the less the liability to injury, either from parching of the surface or from being drowned by excess of moisture.

In well drained soils, therefore, plants are not only better nourished, but also in great measure protected from injury from drouth.

In wet soils, artificial manures are almost wasted, for they will mostly become dissolved in the water which the roots of the plant will not penetrate; but by drainage, the stratum of soil will be increased in depth, and the more effectually will the nutritive matter be absorbed and thus placed at the disposal of the plant.

A thorough circulation of the air in the soil has further the effect of sweetening it by preventing the formation of those acid decomposition products which always collect where decay of organic matter goes on with excess of water; and of promoting the conversion of all into carbonate acid,

which exercises so great an influence in changing the inactive soil ingredients into forms in which they are available to the plant.

Professor Johnston thus summarizes the benefits of draining: A. It is equivalent not only to a change of soil, but also to a change of climate, both in reference to the growth of plants and to the health of the population.

B. It is equivalent also to a deepening of the soil, both by removing the water and by allowing those noxious ingredients to be washed out of the subsoil which had previously prevented the roots from descending.

C. It is a necessary preparation to the many other improvements that may be applied to the land.*

4–5. FALLOWING AND INCORPORATION OF VEGETABLE MATTER.—When a soil has been brought, by continual cropping without adequate restitution, to the point where it can no longer be profitably cultivated, it is well known that a period of rest will often enable it to regain a portion at least of its lost fertility.

All soils, as we have seen, are made up of three classes of constituents: the *mechanical constituents*, such as clay and sand; the *assimilable constituents in actually available form;* and the *assimilable constituents in reserve*, or not yet available. The latter consist of humus and other organic detritus, and of undecomposed rock or mineral fragments, which are gradually decomposed and converted into available form under the combined action of the oxygen and carbonic acid of the atmosphere.

A field will lose its fertility so soon as its stock of plant-food in a soluble or available form is no longer sufficient to supply the needs of the growing crop, and to restore the fertility, it is necessary to increase this stock of available plant-food, which may come either from the soil itself, or be added from outside sources in the form of manure.

The fallow is that period during which the field is left uncultivated, in order that during the process of weathering and decay the inert soil constituents may be dissolved and converted into forms in which they may be assimilable by succeeding crops. The action of the atmospheric agencies is increased by increasing the surface acted on; hence, plowing and continually turning up and exposing new surfaces of soil to the atmosphere, very materially assist the processes of decomposition. The most effective of the

*Agricultural Chemistry, p. 310.

atmospheric agencies is carbonic acid, and where this is most abundant the decomposition goes on most rapidly.

In this way, we may understand how the incorporation of vegetable matter will assist the chemical processes on which the efficacy of the fallow depends. Vegetable matter, turned under, acts in still another way, by increasing the porosity of the soil, and affording more numerous passages by which the atmosphere can have access, and thus greatly increases the surface acted on. And still further, certain deep-rooted plants which derive their nutriment from the subsoil, add this nutriment to the top soil when plowed under.

In considering the efficacy of the fallow, the original composition of the soil itself must be taken into consideration, and if this is deficient in any of the elements of plant-food, it will not be rendered more fertile by fallowing, except in so far as the deep plowing adds new material from the subsoil, or the plowing in of deep-rooted plants accomplishes the same end. The two kinds of fallowing are distinguished as naked fallow and green fallow, according as the soil is left unplanted, or as green crops are cultivated for the purpose of plowing them in, with the double object of improving the physical texture of the soil, rendering it more porous and accessible to the atmospheric agencies, and of adding to the top soil in an available and soluble form, the plant-food which these crops have assimilated from the deeper lying strata.

It is obvious that fallowing and the plowing in of green crops can add nothing to the soil's stock of plant-food; these processes can only render more available the assimilable constituents already present in the soil, and the same is true of the incorporation of stable manure, when it is applied to the same fields which produced the plants from which it was derived. The plowing in of stubble and other remnants of crops *produced upon the field* is evidently only a partial restitution of the mineral and other matters derived from the field, and the same may be said of the use of the cotton seed meal.

The fields are worked during the fallow for the double purpose of getting rid of troublesome weeds, and of increasing the surface of soil exposed to the atmospheric agencies. It is common in some sections to allow the fields to grow up in grass and weeds during the period of rest, and to plow these in when the land is again taken into cultivation. In this way, all the mineral matter assimilated by these plants during the rest period is again returned to the soil, unless the fields are turned out, and cattle are allowed to graze upon them. In this case, as a matter of course, there is an actual loss of fertility, and the fields do not recuperate when turned out.

6. Rotation of Crops.—A soil upon which one and the same crop is planted from year to year, will gradually lose the power of producing that particular crop, while some

other plants will flourish upon it. And even fields which are so far exhausted by improvident cultivation as to be no longer productive of ordinary crops, will still produce what we know as weeds. It is only in certain favored regions, that the same crop can be produced without interruption upon the same spot for any great length of time.

The reasons for the favorable results coming from a rotation of crops are varied, but they all depend upon the fact that by rotation we are able to utilize to the best advantage the nutritive elements possessed by the soil, or added to it in the way of manure. The manner in which rotation of crops accomplishes this end has been very clearly stated by Gohren, in his Agrikultur Chemie, p. 520, and following:

1st. While all plants draw from the soil the same substances, they assimilate the different elements of plant-food in very different degrees. Thus, plants which are cultivated for their roots, require from the soil very much less of phosphoric acid, for instance, than the grain crops, and the latter, on the other hand, require much less of potash for their nourishment than the former. By causing the various cultivated crops to follow each other in the proper order, the farmer is able to utilize completely the plant-food in his soil instead of spoiling it by exhausting it of a portion only of these nutritive elements; for if only one of these elements be lacking in a soil, its fertility is gone.

2d. In rotation of crops, advantage is taken of the varying development of the roots of the different cultivated plants. By reason of the varying depths to which their roots penetrate, different plants are able to draw their nutriment from *different* layers of the soil, and because of the great variety in the mode of development of their roots, different plants utilize in very different degrees the nutriment from the *same* soil stratum. Accordingly grain crops, with their shallow surface roots, should succeed plants with deeply reaching roots, such as clover, peas, etc.

In addition to this, the physical characters of the soil may often be improved by the growth of certain plants; for the deeply penetrating roots of some plants loosen the soil, and render it more porous, having frequently the effect of drainage. And further, where the plants with deep roots are plowed in, the mineral matter which they have assimilated from the lower strata of the soil, are returned to the top soil, where they are presented in a highly available form to a succeeding crop with shallow surface roots.

3d. The kind and quantity of the plant remains such as stubble, roots, leaves, etc., which the different crops leave after the harvest, vary greatly. In a crop of peas or clover, for instance, much less is actually removed from the field and much more returned to it, than in a crop of grain; and in rotation, it is the rule to let a crop which takes much from the field in the harvest, be succeeded by one which takes away comparatively little, and on the other hand, leaves much in the way of stubble, leaves, etc.

4th. Those plants with a great expanse of leaves, such as the leguminous

plants, assimilate from the atmosphere a relatively large proportion of their nutriment, which is added to the soil as a source of humus and nitrogenous matter, which are thus presented to the next succeeding plant generation in an easily assimilable form.

Plants with ample leaf development benefit the ground in still another way, by virtue of the shade they afford, which keeps the soil in good physical condition.

From experiments it appears that the chemical processes going on in the soil, are, to a certain degree, increased with the intensity of the shade; for a good shading of the ground promotes the copious formation of dew, and hinders the evaporation of moisture in the warmer seasons, and thus prevents the dessication of the soil; it affords, furthermore, a protection against the too great radiation of heat at night, and the burning heat of the sun by day, and thus serves to regulate the temperature of the soil. In this way is maintained that moderately moist and warm condition of the soil in which the processes of weathering and decay go on most rapidly.

5th. By the long continued cultivation of one and the same kind of crop, the physical characters of a soil are often so changed, either by reason of the processes of cultivation or by the peculiar nature of the plant roots, as to be no longer suitable for the cultivation of this particular crop, and so a rotation becomes necessary. Thus, by the cultivation of clover, the soil becomes close in texture and in this respect better fitted for the production of wheat, which requires a close soil; and the cultivation of those crops which require much working of the soil, fits it for those crops which demand a loose and porous soil.

In determining the proper order of rotation, these as well as other considerations must have their full weight.

The greater the variety in the crops, the greater will be the advantages of rotation and the longer will the fertility of the soil be preserved, for by judicious rotation the soil, while exhausted, is exhausted to the very best advantage.

II. *Modifications of the Physical and Chemical Properties of the Soil by means of Substances added from external Sources; Manures.*

In all but the rudest and most primitive systems of agriculture it is the universal custom to add to, and incorporate into, the soil, with the object of maintaining and increasing its fertility, substances derived from sources external to the field, and which are called by the general name of *manures*.

A soil is fertile when it contains the elements of plant-food in sufficient quantity and in an available form, and when at the same time, its physical properties are such as to favor the growth of the plant.

Manures, therefore, in order to serve their end, must, on the one hand, contain some or all of the elements of plant-food; and on the other, react favorably upon the physical properties of the soil. The action of manures may, hence, be considered as *mechanical* in modifying the physical properties, and as *chemical* in adding to the stock of plant-food of the soil.

Before passing to the subject of manures in the ordinary or restricted sense of that term, I shall first, for the sake of completeness, speak of two modes of enriching the soil, which are, however, not generally feasible. These are manuring by means of mixtures of soils, and by means of water.

MANURING BY MIXTURES OF SOILS.—Since a soil formed under natural conditions contain all the elements of plant-food, it is readily seen that an exhausted soil might be improved by mixing with it one that was still fresh, and this is done in some measure, in the operation of subsoiling, when the subsoil is brought up by the plow and mixed with the top soil.

But mixtures of different soils, where practiced at all, are rarely made with a view to adding to the stock of fertility, so much as with a view to modifying in some way the physical properties of the soil. It is rarely, if ever, the case that it will pay to haul sand, for instance, to mix with a heavy clay soil to make it lighter and more easily worked, for a soil thus improved would cost in the end more than would be needed to purchase an equal area of the very best land. In certain cases, however, advantage may be taken of the topographical relations of a field to effect this improvement by means of running waters. Where heavy intractable clay soils lie at the base of hills, formed chiefly of sands, the washings from these hills are well known to be advantageous to the clays. By turning the channels of the streams so as to spread this wash over a wide area, a permanent improvement may certainly be effected. Such is the condition of things along the borders of the Post-oak Flatwoods in Alabama, where they lie adjacent to the red loam hills.

The improvement of light, sandy soils by admixtures of clay is attended with still more difficulty and expense, and can hardly be considered as practicable.

But the heaviness of clay soils and the opposite qualities of sandy soils are both corrected by the incorporation of vegetable matter, such as leaves, stubble, green crops, humus, and stable manure, though these substances play a much more important role by virtue of the elements of plant-food which they contain in a highly available form.

MANURING BY MEANS OF WATER; IRRIGATION.—The manuring effects of a mixing of soils are naturally dependent chiefly upon that portion of the added soil which is the carrier of the nutritive salts, and upon which those physical properties of greatest advantage to the growing plant are most closely dependent. This is, of course, the fine earth or that fine clayey portion of the soil which remains long suspended in slowly flowing water, and which slowly settles when the water comes to rest. The sediments deposited by the periodical overflows of the Nile, the Mississippi, and other large streams, have served to keep up the fertility of these favored regions in a surprising degree for a great length of time. In some sections muddy water is conducted by artificial means over the land, and allowed to deposit its sediment, after which it is drawn off. A frequent repetition of this will often greatly increase the fertility of a field.

Even clear water, when caused to spread over fields, is made the means of increasing their fertility by virtue of the salts it holds in solution, and when, instead of clear water the muddy sewage water from cities, containing matters both in solution and in suspension, is thus used for irrigating purposes, the results are often still more favorable, provided the water contains nothing in itself injurious to vegetable life. In a State like ours, these modes of improvement of the soil, except in the immediate flood plains of our streams, lie probably in the far distant future. The addition of the vegetable matter in the form of humus or otherwise, contained in such muddy waters, also exerts a favorable action upon the physical structure of the soil.

Manures Proper.

The various substances commonly used as manures fall into two great classes,* viz:

I. *Absolute or complete manures*, which contain all the elements of plant food, especially the most important, in sufficient quantity and in a form in which they are easy of assimilation, and which moreover, exert a favorable action on the physical properties of the soil.

Such are—

1. Vegetable matter, Stable manure, and Composts.
2. Night Soil.

II. *Relative or incomplete or partial manures*, which do not contain all the elements of plant food; and whose physical action on the soil, is one-sided or partial; or which are used specially because of their physical action.

And the partial manures are still further subdivided into *Nutritive manures*, or those which are directly fertilizing; and *Stimulant manures*, or those whose fertilizing action is chiefly indirect.

The Nutritive partial manures usually contain most of the elements of plant food, but depend for their action principally upon one only, and when classified according to the dominating constituents, they may be arranged as follows:

1. Nitrogenous Manures.
   Peruvian Guano, Fish Guano, Bat Guano, Other Animal and Vegetable Refuse, Salts of Ammonia and Nitric acid.
2. Phosphate Manures.
   Phosphatic Guanos, Mineral Phosphates, Phosphate rocks of South Carolina and Florida, Bones, Superphosphates, Precipitated phosphate of lime.
3. Potash manures.
   Stassfurth Potash Salts, Greensand, Ashes, Organic Refuse, Soap Boilers' Refuse, etc.

The Stimulant manures are those whose chief effect is to render available the elements of plant food already present

*Heiden, Lehrbuch der Duengerlehre, II. p. 5.

in the soil; their fertilizing action is therefore indirect. The principal stimulant manures are—

1. Carbonaceous Manures.
   Humus, Vegetable mould, etc.
2. Calcareous Manures.
   Gypsum, Quick lime, Carbonate of lime, Marls.
3. Saline Manures.
   Common salt, Other Salts.

I. Absolute or Complete Manures.

(1.) Vegetable Matter; Stable Manure; Composts.

We have spoken above of the effects gradually produced upon a soil, in the course of nature, by the incorporation into it of the leaves and other vegetable refuse produced upon the spot. In general, these effects may be summed up as consisting, 1st. Of a restitution to the top soil in a highly assimilable form, of the elements of plant food brought up by the deeply penetrating roots from the subsoil and underlying strata; 2nd, of an accumulation in the soil in the tissues of the vegetation, of the nitrogen assimilated by it from the atmosphere, in addition to that which it derived from the soil; 3rd, an improvement in the physical qualities of the soil; 4th, an increase in the extent of surface exposed to the action of the weather and a consequent increase in the products of weathering, *i. e.*, in the amount of nutritive salts; and 5th, an increase in these, due to the additional source of carbonic acid introduced into the soil, in the decaying vegetable matter. The main effect, therefore, seems to be a stimulating one, by which the insoluble constituents of the soil are decomposed and turned to account for the purposes of the plant, and by which these elements of nutrition are gradually accumulated in the surface soil.

So long, then, as none of the material is removed from the spot where it was produced, the result is a continual improvement of the surface soil; but where any of the material fails to be restored, the result of the incorporation of vegetable matter, is seen to be an improvement of the sur-

face soil at the expense of the deeper lying layers, to be merely stimulating in fact. But if, year by year, additional vegetable matter, in the form of leaves, straw, stubble, etc., from outside source is incorporated into the soil, in excess of that removed in the harvests, a permanent improvement of the land will be effected.

Green manuring alone, with vegetation produced on the spot, in any system of agriculture, will not suffice to keep up the fertility of the soil, where crops are regularly removed therefrom.

Stable manure is only vegetable matter, modified by its passage through the bodies of our domestic animals; and in order to understand clearly the difference between a manuring directly by the green crops, and a manuring with the animal excrements derived from these crops, it will be necessary to learn something of the changes in chemical composition and other properties, which a mass of vegetable matter undergoes during its passage through the animal body.*

Leaving out of account for the present, that portion of the food which is converted into flesh and blood, and the other tissues of the animal, it may be said in general, that the difference between that which is taken in as food and that which is discharged as excrement, is seen first in a very considerable loss in the organic matter, which is consumed in the lungs in the process of respiration; secondly, the nitrogenous and mineral constituents are unaltered in quantity, but appear in the excrement in an essentially different form.

The loss in the organic matter constitutes about half of the gross weight of the substances used as food. The *carbon* of this half is completely oxidized to *carbonic acid* in the process of respiration, and is given out to the atmosphere in exactly the same form in which it was originally assimilated by the growing plant. The rest of the organic matter forms the principal part of the solid excrement, and consists of the undigested portions of the food which have not entered at all into the circulation of the animal.

The urine contains almost exclusively those liquid and solid excretions which are the last products of the physiological processes, and contains comparatively little organic matter in the usual sense of the word.

The *nitrogen* of the food, in the process of digestion, is not eliminated in the form of free nitrogen—as is in part the case when nitrogenous organic matter suffers oxidation outside of the animal body—but in combination with carbon and hydrogen, it is rejected from the body in the form of *urea* and other substances of similar composition, which may be considered as ammoniacal compounds, since they resemble ammonia in their chemical composition, and when they undergo decomposition they give off large quantities of this gas.

*Mayer, Agrikultur Chemie.

We see, therefore, that the nitrogen of the food, in so far as it is not assimilated, passes out of the animal body in a form in which it is easily absorbed and assimilated by the plant.

The *mineral matters* of the food also, pass partly into the circulation, and are in part rejected from the body in unchanged form. That portion which is taken into the circulation, in so far as it is not assimilated, is also eliminated in a condition in which it is much more available to plants, than in the original organic matter which served as food.

In general, then, *vegetable matter in its passage through the animal system, suffers a loss of about one half of its organic matter; the nitrogen and the mineral constituents appear in the excrement in almost undiminished quantity but in a highly available form.*

By this loss of organic matter the excrement is rendered less efficacious than the original vegetation, as a source of carbonic acid, and of humus, and in producing those modifications of the physical properties of the soil which depend upon the accumulation of humus in it; but since in most cases, this is of comparatively little moment, it follows that as a rule, the excrement may be used as a manure more profitably than can the vegetable matter in its original form.

Of course, there may be soils so deficient in vegetable matter, as to stand in more need of it, as a corrective of adverse physical qualities, than of the elements of plant-food, but as a rule they are much more likely to owe their lack of fertility to a deficiency in mineral nutritive matter, and especially in nitrogenous matter.*

In the stable, straw, leaves, or some other similar substance, as litter, is used primarily for the purpose of absorbing the fluid portion of the excretions, and the value of the stable manure will depend, also, largely upon the nature of the absorbent, which not only soaks up and retards the decomposition of the fluid matters, but which itself gradually falls into decay and thus adds to the sum of the fertilizing constituents of the manure.

And naturally, the richer the absorbent is in these elements of plant-food, the greater will be its value in this respect.

But the straw or litter fulfills another office in stable manure, by virtue of its efficiency in modifying the physical characters of the soil to which it is applied, giving more coherence to loose soils, lightening heavy ones, etc.

The other advantages of decaying vegetable matter in the soil have been sufficiently dwelt upon above. As a com-

*For the above clear statement of the modifications of vegetable matter experienced during the passage through the animal body, we are again indebted to Mayer, Agrikultur Chemie.

plete manure, it will be difficult to find anything which can act as a substitute for stable manure.

But not a little of the efficacy of stable manure depends upon the manner in which it has been collected and preserved, and its condition when applied to the field.

Stable manure, as we have seen, consists of a liquid and a solid portion; and as both contain valuable ingredients, care must be taken that there is as little loss as possible of either. The sources of loss are—1st, the soaking into the ground of the liquid portion with its dissolved salts, or the washing out and scattering of it by rains; and 2d, the loss due to escape of the volatile or gaseous products arising from the decomposition of the manure while lying in the farm yard. To guard against these evils, provision should be made for conducting the liquid portion to a water-tight reservoir without loss on the way; and to prevent evaporation and too great dilution by rains, it is often best to provide the heap with some sort of shelter.

But the organic matter undergoes chemical decomposition; the solid portion, litter, etc., pass into a friable, soft, easily decomposable condition, carbonic acid and ammonia are generated among other things, the former usually is allowed to escape, but as ammonia is one of the most valuable of the constituents, measures should be provided for its retention. To this end the solid part of the manure is sometimes heaped in piles, which should not, however, be too high, four or five feet at most.

From time to time the liquid portion of the manure is pumped or otherwise spread over the pile in oder to secure more complete absorption, or the pile is covered with earth, which is a good absorbent of ammonia and other gases, or else some substance is added which will chemically fix the ammonia, such as sulphuric acid, gypsum, etc. Quick-lime sets free ammonia from its compounds, and an excess of it should, therefore, be avoided, though in moderate quantity it may be profitably used. With all precautions, however, it is impossible to prevent the loss of some of the ammonia.

The ash ingredients, that is, the mineral matters, are not subject to any loss except from soaking into the ground or washing away by reason of defective construction of the drains and other parts. The changes which fresh stable manure (with the precautions above noted against loss of valu able constituents), undergoes during partial decomposition, may be summed up as consisting in a loss of part of the vegetable or organic matter, a consequent increase in the percentage of the mineral ingredients, and an increase in the amount of nitrogen in an available form, the last being due to the changes produced by decomposition.

It has been estimated that by lying in the farm-yard, the loss from evaporation and escape of volatile matters by fermentation, by the time the straw is half rotted, amounts to *one-fourth* the whole *weight*, while the *bulk* is diminished *one-half*. If allowed to lie still longer, the loss in weight increases till at last it may be about one half.*

The quality of the manure as described above depends also upon the animal producing it, the age of the animal,

*Johnston, Agricultural Chemistry, p. 174.

the quality of the food given, etc., all of which must be taken into account in estimating the value of the manure, and in determining the manner of its application. In a general way, it may be asserted that the concentrated manures, especially those rich in nitrogen, like the excrement of the sheep and horse, are heating, and are to be applied to cold soils, while the less concentrated manures, like that of horned cattle and the hog, are best used upon light, warm soils. By this it is not to be understood that there is any actual heating of the soil due to the fermentation of the manure, but the explanation is rather to be sought in the differences in the absorptive powers of the two kinds of soils. (Mayer.)

Warm soils, as seen above, are light, porous and dry, like the majority of sandy soils, and with comparatively little powers of absorption. A strong manure upon such a soil can easily become more concentrated, and consequently injurious to the plant, and can moreover easily lose a part of its soluble ingredients by rain, etc. This is not to be feared in the case of a soil which is heavy, clayey, or rich in humus, and possessed of great powers of absorption.

Similarly, whether the manure is best applied in a fresh or in a decomposed state, will depend on the circumstances.

Where the soil is close or heavy, and the main object in view its general enrichment, then it is most economical to apply the manure in a fresh state, with its full content of organic matter. But where the soil is already light, and porous, and open, the addition of fresh manure would intensify these qualities, and thus easily prove injurious. In such a case, it might be more profitable to allow the manure to rot in the fields before plowing in, even with the certainty of considerable loss from fermentation. In the case of loamy or clayey soils, moreover, the products of decay of the fresh manure are more completely absorbed.

The character of the crop will also determine the kind of manure to be used, whether fresh or rotted. For all plants of short periods of vegetation, such as tobacco, garden vegetables, etc., which need a quickly-acting manure, the well-rotted material is best. Winter grains, and all crops which remain for a long time in the ground, are best treated with

fresh or only partially rotted manures, on account of its slow and long continued action.

Climate and weather are likewise to be taken into consideration, for, in dry weather, fresh manure remains almost without effect, since moisture is needed for its decay and for the conversion of many of its ingredients into available forms.

The liquid and solid parts of stable manure are sometimes separately used, and in determining the relative fitness of the two, the following general principles are applicable: Liquid manures have no action upon the physical properties of the soil; all their ingredients are in a soluble form, and highly available to the plant, and moreover in concentrated form. Where quick results are desired, the liquid form is therefore preferable. Liquid manure is used to advantage upon all soils, but on light, sandy soils of little absorbing power, it should be applied in small quantities, but often repeated; otherwise loss will ensue. On heavy, clayey soils of great absorptive power, larger quantities can be used, but less frequently. As liquid manure has no effect on the physical properties of soils, it would not answer to use this form of manure exclusively upon heavy soils.

It is customary in most places to add to the manure pile other substances designed to increase its content of valuable elements of plant-food, and at the same time to prevent loss of volatile products of decomposition, especially ammonia. The humus which is produced in partial decomposition of the litter of the stable manure, is a good absorbent, as has already been seen, but its quantity is not usually sufficient to prevent loss of some of the ammonia generated by the decay of the animal matter of the manure pile. I have already spoken of the use of gypsum and dry earth in this connection, but better results are reached by *composting*, as it is called. Instead of earth or clay as an absorbent, other materials may be profitably used, which at the same time supply nutritive mineral ingredients in larger quantity. Chief among these may be mentioned marsh or pond muck, and lignite, which is so abundant in the Tertiary formations of Alabama. The calcareous and gypseous marls,

also abundant in the same sections of the State, have been very highly recommended. The use of quick lime, or the carbonate, in moderate quantity, according to Dr. Hilgard, favors the retention of ammonia, and at the same time hastens the decomposition of the organic matter, and in the case of the calcareous marls, the favorable action is not only exercised by the marl on the manure, but *vice versa*, by the decaying manure upon the marl, by which its alkaline ingredients are rendered more soluble, and therefore more rapidly available to plants by the combined action of carbonic acid and ammonia.*

An excess of lime, on the other hand, would inevitably cause the rapid liberation of ammonia and perhaps some loss.

Other ingredients added to the compost heap for the purpose of increasing its content of nutritive matter, are animal and vegetable refuse of all sorts, such as leaves, pine straw, blood, hair, feathers, weeds, and, in our section, cotton seed. In addition to these, mineral matters containing phosphates and salts of potash are common constituents of compost heaps. "The receipts for these composts are very numerous; they prove that the discovery of a compost is an easy matter, and requires but a small amount of ingenuity. To unite different matters in such a way as to obtain a compound that shall act advantageously, it is only necessary to make it up of substances which of themselves and isolatedly are good manures. But that it is possible to supply the scarcity of manure, to create it in some sort by means of composts, is a subject of dispute. In fact, when we look attentively at the numerous mixtures which have been indicated as leading to this end, we always perceive that the proposal amounts to an extension or dilution of some powerful manure with a substance that is either inert or has little activity. This mode of proceeding may have its advantages; it enables us to make a more equal distribution of the manure we have at our disposal, but it actually supplies us with none."†

*Hilgard, Geology of Mississippi, p. 237.

†Boussingault, Rural Economy, p. 390.

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It seems hardly necessary to speak of any particular formula for composting, but the following seems well adapted to use in the Southern States, and is recommended by Professor Pendleton, in his Scientific Agriculture:

First, a layer of stable manure six inches thick, with a good sprinkling of ground super-phosphate over it; then a layer of cotton seed three inches thick (previously saturated with water), and then another sprinkling of super-phosphate, say half an inch thick; then a layer of stable manure, and so on till the heap is completed. The formula recommended by Mr. F. Furman is the same as the above, with the exception that he mixes *kainite* (a sulphate of potash and magnesia) with the super-phosphate before adding it to the heap.

(2). Night Soil.

A little reflection will show that in stable manure, a part only of the mineral ingredients are restored to the soil, which were taken from it by the growing crops, and thus results a constant drain upon the land. "It may be asked, "what has become of the indestructible matter which formed "the original stock of fertility now lost by mismanagement? "The answer will readily suggest itself to every thinking "man, when he considers what is the ultimate destination "of agricultural products, viz., to serve as food and raiment "to man. Whatsoever we feed to our stock, is partly con- "sumed by man as meat, milk, cheese, eggs, etc., partly "returns to the fields through the manure pile—diminished "by the amount contained in our food, each time it thus "circulates. For, unfortunately, night soil, the most effica- "cious of manures, is thus far mostly regarded as a nuisance, "to get rid of which is a problem which has occupied much "ingenuity and talent. Our privies and the sewers of our "cities, are undeniably the channels through which the "fertility of our lands is either drained into the ocean, or "else accumulated in receptacles, which, by common con- "sent, are held as being among the most unpleasant neces- "sities of our fallen state; yet they are in reality so many "Guano Islands, whose benefits we can realize with only a "nominal cost of transportation."

"In the conscientious utilization in agriculture, of human "excrements, both fluid and solid, together with bones, "dung, and all other offal, now partly used for these pur- "poses, we have, beyond a doubt, the only universal pre- "ventive of the exhaustion of cultivated lands. For it is

"they into which almost all the products of our fields are "ultimately transformed, and in them we shall, therefore, "expect to find all that has been withdrawn from the "former."

"And if, instead of eatables, we raise cotton, we shall have "to import a corresponding quantity of provisions; these, "when transformed into night soil, would more than replace "all the drain on our lands caused by the cotton crops, if "properly distributed."

"It may be objected, that if we were to husband the mate- "rial in question, as the Chinese have successfully done for "ages, we should have to change our habits, and blunt "some of our senses, and delicacy, to an alarming extent. "Fortunately, the science which has annihilated space, and "compelled lightning to be the messenger of thoughts, does "not abandon us in this problem, momentously simple as it "is. The use of disinfecting agents (many of which them- "selves enhance the value of the material for agricultural "purposes), in connection with the proper mechanical con- "trivances, would enable us, even at the present moment, to "preserve these valuable fertilizers without any serious "offense to our delicacy, if we would but introduce, in this "respect, a regular, uniform system; and if we are to judge "by analogy, we can scarcely doubt that more perfect con- "trivances for the purpose, would be forthcoming so soon "as the demand for them should become general and urgent."

"On the continent of Europe, the agitation of this subject "has already been attended with the most beneficial re- "sults."

"It would be extravagant to expect that such a system "should be universally established in this country, until the "necessity shall have been more keenly felt. But we have "this great advantage, that in our agricultural population, "there is less settled prejudice and routine to overcome, "than in Europe. They are eager and willing to accept the "teachings of true science, and we may hope with some con- "fidence, that by a timely application of these to practice, "the ills which now weigh down a large part of the agricul- "tural population of Europe, may be avoided." (Hilgard, Geology of Mississippi, p. 251.)

2. *Relative, Partial, or Incomplete Manures.*

A. Directly Acting or Nutritive.

(1). *Nitrogenous Manures.*

Peruvian Guano.—The excrement of all birds is usually rich in nitrogen and phosphates, and particularly is this the case with the flesh-eating birds, such as the eagle. Upon the islands and part of the mainland of the western coast of South America, fish-eating birds have nested for centuries, forming by their excretions, remnants of food, dead bodies, etc., great accumulations, many feet in thickness, of a highly nitrogenous substance called Peruvian Guano. The conditions rendering possible the existence of such masses, are absence of rain, and an abundance of fish for food of the birds. When similar accumulations are made in a different climate, the material undergoes decomposition, which is favored by the presence of moisture, and much of the nitrogen passes off in the form of ammonia. Such is the case with the inferior grades of guano found on certain parts of the South American, Australian, African, and Asiatic coasts. Even the genuine Peruvian guano has a very variable composition, due to the number of materials which have contributed to its formation, to the action of moisture (dew) continued for long periods, and to the particular layer of the deposit from which taken. In the transport, guano is sometimes damaged by sea water, by which a rapid decomposition is set up, attended with escape of ammonia and other volatile products.

Genuine Peruvian guano is a fine grained powder, of light yellowish to coffee brown color. It has a greasy feel, and usually contains small lumps harder than the rest of the mass. These lumps sometimes have the same composition as the rest of the guano, sometimes consist of oxalate and urate of ammonia, sometimes of alkaline salts. The peculiar smell of guano is due to salts of ammonia, and to decaying organic matter. When strongly heated, about half of it volatilizes and the rest dissolves in acid with very little residue.

As a mean of very many analyses, the following, taken from Mayer,* will show the average composition of good Peruvian guano.

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*Agrikultur Chemie, p. II, p. 255.

Water	14.8
Organic matter, including salts of ammonia	52.4
Nitrogen	14.4
Phosphoric acid	13.5
Alkaline salts	7.4
Ash	32.8

In all the guano of this class, Nitrogen and Phosphoric acid are the chief valuable ingredients. The content of Potash salts is also quite high, but is by comparison, far below that of the other two constituents named, and guano is therefore classed with the partial or incomplete manures.

As remarked by Dr. Hilgard,* the amount of guano used on land is usually small, and the quantity of potash salts thus applied with it, never enough to have any appreciable effect upon the soil if it be in good condition. The whole action of the guano is thus due to its ammonia and phosphates, and more especially to the former; it is chiefly stimulant, inciting the plant to a rapid assimilation of nutritive ingredients.

About half the weight of good guano is soluble in water, and consists of salts of ammonia chiefly, among which the oxalate and urate predominate. Both the oxalic acid and the ammonia may be considered as products of the decomposition of uric acid, a constituent of the excrement of birds.

Guano is an extremely concentrated fertilizer, and on this account might be classed with the complete manures, as is sometimes done; it is applicable to most varieties of crops, and particularly in cases where strong action, and immediate results are desired. On account of its concentration, precautions must be taken to secure uniform distribution when it is applied to the soil.

It shares with liquid manures and night soil, a high percentage of ammonia and phosphoric acid, and like them has no effect in modifying the physical characters of the soil.

In some cases, guano is treated with sulphuric acid for the double purpose of rendering more soluble its phosphoric acid, and of fixing the ammonia, especially when the guano has been wet by sea water, and a loss of ammonia by fermentation is to be feared. Guano treated in this way has about 10 per cent. of soluble phosphoric acid and about the same of nitrogen.†

*Geology of Mississippi, p. 226.

† Mayer, Agrikultur Chemie, II. p. 258.

According to the proportion of sulphuric acid used, this is called "sulphated," "ammonia-fixed," or "dissolved" guano.

On account of its high per centage of nitrogenous matter, guano is a highly stimulating manure, and mixtures are often made of it with other fertilizers less rich in ammonia, which are known as "manipulated guanos."

FISH GUANO.—Other varities of "artificial" guano, consist of the refuse of fish, crabs, and other marine animals, and are often of a value approximating that of the genuine Peruvian.

BAT GUANO.—In many of the caves in different parts of North America, Hungary, Sardinia, and other countries, is a kind of guano consisting of the excrement of bats.

An analysis of such a guano from a cave in North Alabama, gave the following result:*

BAT GUANO.

Moisture	61.02
Organic matter and combined water	26.47
Phosphoric acid	2.27
Sulphuric acid	.22
Ammonia	.67
Nitrogen as Uric acid, etc.	5.80
Lime	1.52
Magnesia	.17
Potash and Soda	1.45
Insoluble matter, sand, etc.	.34

There is not, apparently, sufficient quantities of this substance to make it an object of commercial importance.

"Pacific guano" is an artificial product made of a mixture of South Carolina phosphates, and the bodies and other refuse of fish. (Hoffmann- Gohren, Agrikultur Chemie, I. p. 420.)

OTHER ORGANIC NITROGENEOUS SUBSTANCES.—*Animal Refuse.*—The most important of the materials included under this head are hide, hair, flesh, blood, hoofs, wool, feathers, also the entire carcasses of various animals, and the waste from some technical establishments. In some parts of South America and elsewhere, where animals are slaughtered for their hides, or for the purpose of making meat-extract, the

* Report on Geology of Alabama, 1877-78, p. 138.

greater part of their bodies is worked up into a preparation which goes by the name of guano, (Saladero guano, Fray-Bentos guano) and is essentially a nitrogenous phosphatic manure containing 6.8 per cent. of nitrogen, and 13 to 18 of phosphoric acid. To these, bone meal is often added.

Dried blood, flesh, entrails, etc., containing from five to twelve per cent. of nitrogen, and a notable quantity both of potash and of phosphoric acid, from one-half to one per cent.

The skin and its various appendages, as horn, hair, hoofs, feathers, etc., contain from 10 to 15 per cent. of nitrogen and small quantites of potash and phosphoric acid.

On account of the difficulty with which these last undergo decomposition, it is the custom to subject them first to the action of superheated steam, by which they are rendered brittle, after which they are easily reduced to powder, and in this form applied to the land, or else they are composted with stable manure and allowed to decay in mass before using.

Vegetable Refuse.—The most important among these are oil-cake, waste from technical works, such as breweries, starch manufactories, sugar works, etc. The best known in this part of the world, is the cotton seed oil-cake, which contains from three to four per cent. nitrogen, one to two of alkalies, and three to four of phosphoric acid. The other varieties of oil-cake have similar but slightly varying composition. These materials belong to the rapidly acting, but not lasting manures, and are best suited to light, and moist soils. In the case of heavy soils a large quantity is needed, and a little lime added assists the action. They are usually applied after being reduced to meal or coarse powder, and either alone or soaked in liquid manure; or else they are composted with other substances.

On account, however, of the value of cotton-seed and other similar material as food for cattle, they are usually first fed to stock, and are applied as manure in the form of dung.

Cotton seed, either entire or in the form of meal or cake from which the oil has been pressed, is one of the staples of the Southern States, and I need make no apology for intro-

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ducing here the results of recent experiments of Dr. Hilgard, intended to throw some light upon the question, "how shall the cotton seed be used?"

When cotton seed is heated in large piles the seeds are killed, the kernels become brown and shrivelled, and a strong odor of ammonia is given off. To prevent the loss of this most valuable fertilizing principle, the seed is sometimes put into the earth, where the escaping ammonia may be absorbed by the soil, or else the seed is composted with stable manure, and gypsum or other suitable absorbent. In the former practice, it has been found that the fresh seed or the oil cake put in the ground, is liable to kill the young seedlings in the immediate neighborhood. This has commonly been attributed to the excessive evolution of ammonia, but Dr. Hilgard's experiments show that when the seed or meal was allowed to ferment, a notable quantity of very ill-flavored alcohol is produced, to which the deadly effects upon young plant roots, of fermenting cotton seed, may in great measure be attributed. To provide against this danger it is advisable to allow the heating of the seed, or of the oil cake, to take place out of the ground, taking care of course that the fermentation of the mass be stopped short by drying or other means before the evolution of the ammonia begins.

Meal not previously heated may be used with impunity, provided it be mixed with a large proportion of earth.

In connection with the same experiments, it was found that when the meal was first composted with plaster or gypsum to absorb the ammonia, and then allowed to sour, it acts most energetically upon bone meal and even upon bone ash, in rendering them efficacious as fertilizers, thus replacing in very good measure the sulphuric acid used for the same purpose by the manufacturers of ferilizers, but at merely nominal expense, and at home.

Decomposition of the Whole Seed in the Soil.—Another series of experiments showed that seeds that had been used under a seed-bed of sweet potatoes were found six months afterwards, to be in great proportion still whole, but quite light, and containing brown, shrunken kernels, which, on analysis, were found to contain fully 75 per cent. of the mineral ingredients of the original seeds. It was plain, that during all this time the sweet potatoes and the weeds following them, had been unable to extract from the oily seed more than a small proportion of their plant-food, but had been benefited chiefly by the ammonia that had been given off in the shape of gas at first; and that subsequent crops would get the chief benefit of this plant-food in succeeding years.

This result is in accordance with the oft-repeated assertion that cotton seed put in the ground whole, benefits corn more than cotton during the first year. Corn will bear a heavy application of ammoniacal manures, whereas cotton is liable to run to weed, and boll poorly under their influence.

After the corn has taken up the ammonia during the first season, the cotton gets the full benefit of the phosphates and potash the second year.

Experiments show, in addition, the benefits of removing the oil from the seed when desired for manure. The entire kernel is completely "preserved

in oil," during the first season, and resists the decay which would render its ingredients accessible to plants, whereas, when freed from the oil, as in oil cake meal, the process of decomposition is unchecked and the entire stock of plant-food goes to the use of the crop the first season. This is an additional reason for converting the spare seed into oil cake meal, even for manurial purposes.

It is well known, further, that the oil contains nothing but *carbon*, *hydrogen* and *oxygen*, three substances which the plant assimilates from the atmosphere, while the oil cake contains all the mineral ingredients which the plants extracted from the soil, so that in returning the oil cake meal to the soil, the fullest restitution is effected.

Indirect Return through the Manure of Animals Fed upon the Oil Cake Meal or the Whole Seed.—The manure of cattle fed upon cotton seed or oil cake meal is of special value as a fertilizer for cotton, and should, therefore, be carefully preserved from waste. By far the safest method of obtaining complete returns to the soil is, in this case as in others, the use as feed for sheep, which distribute the fertilizer in the most perfect manner, at the same time producing another fibre—wool—from the refuse of the same field that grew the cotton.*

Street sweepings, turf, muck, and a great variety of other waste or rubbish, containing notable percentages of Nitrogen, may also profitably be used as manure.

SALTS OF AMMONIA AND NITRIC ACID.—Among the most concentrated of the nitrogenous manures are the nitrates and the salts of ammonia, which have lately come into use. Of these, the nitrate of soda or Chilian saltpetre, and the sulphate of ammonia, are principally used, because of their relative cheapness as compared with the other salts of nitric acid and of ammonia. The potash or common saltpetre is also used, but costs more.

Purified saltpetre contains from 15 to 16 per cent. of nitrogen. In the manufacture of dynamite there is a waste product containing 8 per cent. of nitrogen, which is lately in some places coming into use as a nitrogenous manure. The Chili saltpetre occurs in great quantities along the western coast of South America, and is supposed to have originated from the nitrogen of the guano deposits which covered the shores of a great natron lake.†

The sulphate of ammonia which is used for agricultural purposes is chiefly obtained from the ammoniacal liquids of the gas works, and the crude material contains from 77.7 to 93.2 per cent. of sulphate of ammonia, corresponding to 16.5 to 19.8 per cent. of nitrogen.

* Manuscript communication from Dr. Hilgard.

†Hoffman-Gohren, Agrikultur Chemie, p. 468.

The vast quantities of gas given off from our coke ovens, bring about a loss of ammoniacal substances which, if saved, would be of inestimable value. In some sections the ovens are so constructed as to permit of the condensation of the ammonia as well as of the other products now allowed to go to waste. These bye-products have become in themselves a source of wealth which cannot long escape the attention of our manufacturers.

The nitrates and ammonia salts have a double action; first, *directly nutritive* in the nitrogen which they contain, and secondly, *indirectly stimulating* by acting on insoluble compounds in the soil, converting them into soluble forms. When the potash saltpetre is used, the potash also is directly nutritive. The soda is less active, and the same is true of the sulphuric acid of the ammonia salt.

The action of these salts, when applied as manure, is quick but not lasting, while the nitrogenous animal and vegetable matters above mentioned, being in general slow to decompose, act slowly, and for a long time, matters which are to be taken into consideration in selecting the particular form of nitrogenous manure which is to be used in any case.

NATURAL SOURCES OF THE SUPPLY OF NITROGENOUS PLANT-FOOD.—It has been demonstrated by experiments that plants are not capable of assimilating the free or uncombined nitrogen from the atmosphere, but are dependent for their supply of this indispensable element upon the combined nitrogen existing in the soil, and derived ultimately from the small traces of nitric acid and ammonia contained in the atmosphere. Under natural conditions the mineral and other ingredients assimilated by a growing crop are returned to the soil upon the decay of the vegetation, but where part of the crop is regularly removed, the soil is rapi drained of its contents, especially of nitrogenous pl food.

The stock of combined nitrogen in the world is relat small, and the processes by which it is renewed are slow tedious, and we should naturally expect to find som vision by which it is economized and shielded from but such is far from being the case, as the followin will show. The long continued experiments of I Lawes and Gilbert and others have demonstrated, tl

combined nitrogen in the form of nitric acid and ammonia, which was deposited by rains, snow, etc., upon an acre of ground, was less than the nitrogen removed from the same acre in the form of crops; and still further, that even the drainage water from cultivated soils, contains a much larger amount of nitrogen than is supplied to the land by the rain and dew. In these experiments the insufficiency of the atmospheric supply of nitrogen, and of that already present in the soil in the form of nitrogenous organic matter, was fully shown.

And not only so, but when such organic matter undergoes decay, a part of its nitrogen is converted into ammonia, but another part escapes as free nitrogen, and is thus lost to vegetation; and that which is converted into an assimilable form is rendered soluble far more rapidly than it is required or can be utilized, by the growing crops, and is washed down and carried into the drainage water, passing ultimately into the sea.*

As the result of a long series of experiments, it has been shown that when ammonia was applied to the soil as manure in the autumn, two-thirds of the nitrogen was not recovered in the crop, but passed for the most part into the drainage; and when nitrates were applied in the spring, the loss, though not so great, was still more than half of the whole amount applied. Upon analysis, a small proportion of the nitrogen was found to be absorbed by the soil, and in this way preserved for the use of succeeding crops. In the drainage experiments at Rothamsted, it was also found that although large quantities of ammonia salts were applied to some of the plots, the drainage water from these contained mere traces of *ammonia*, but at all times of the year *nitrates* were present in quantity; from this it would appear that it is chiefly, if not solely, from *nitrates* that crops build up their nitrogenous organic constituents. Potash and phosphoric acid, the most valuable mineral constituents of the manures, passed but little into the drainage water, but were retained almost entirely in the land, while the more abundant and less important mineral matters, such as lime, magnesia, soda, sulphuric acid, and soluble silica, passed in large quantities into the drainage waters.

It follows from these investigations; first, that much more nitrogenous material must be applied to the land than would be needed to produce a given increase in the crop, supposing all the nitrogen to be recoverable; and second, that the nitrogenous organic matters, when applied to the soil, undergo decomposition, and are gradually resolved into ammonia compounds, which, after being retained a short time by the soil, are finally oxidized into nitrates, in which form they are most available and beneficial to plants, but not being absorbed by the soil, are readily washed out by rain.†

*London Journal of Science, July, 1883.

†A. Voelcker, in Article *Manure*, Encyclopædia Brittanica, Ninth Edition.

APPLICATION OF NITROGENOUS MANURES.—Nitrogen has great forcing powers, and is usually thought to be most beneficial when applied to crops in their earlier stages.

The good effect of ammoniacal manures upon crops at this period of their growth, is in part also, due to the leaf-producing powers of nitrogen, by which a good and vigorous "stand" is secured. In later stages this kind of manure retards the processes of blooming and fructification, and causes the plant to "run to weed." "It is well known," as remarked by Dr. Hilgard, "that the most decidedly favorable effect is produced by this class of manures, on those crops whose surface of leaf is comparatively *small*—such as wheat and the cereals generally—while their effect is less noticeable with plants naturally very leafy. . . . In coincidence with this rule, we observe that the same land which causes cotton to "run to weed" will produce the most abundant crops of corn."*

Nitrate of soda, unless applied just at the time when the crop is ready to take it up, is largely wasted in drainage, while ammoniacal manures, when used for winter grain, are best applied in the autumn. The gradual decomposition of farm-yard manures gives a more constant supply of nitrogen than the fertilizers already noticed, and as the fermentation of dung proceeds but slowly, it is best to apply it when quite fresh in autumn or winter, allowing it to decompose in the land, and to yield nitrogen as nitrates, when required in spring by the fresh growth of vegetation. In the case of nitrogenous organic materials, such as wool or hair refuse, which take even longer than farm-yard manure to decompose, it is necessary to apply them some three or four months before the seed is sown.†

The following table, taken from Hoffmann-Gohren, (Agrikultur Chemie, p. 470,) shows the percentage of nitrogen in the various substances commonly used as manure:

22 to 20 per cent. Sulphate of ammonia.

17 per cent. Best Peruvian Guano.

15 to 10 per cent. Good Peruvian guano, fish guano, potash and soda saltpetre, hair, dried blood, feathers, horn, wool shearings, refuse of tallow manufacture.

*Geology of Mississippi, p. 226.

†Voelcker, l. c.

15 to 5 per cent. Woolen rags, bat guano, leather remnants, hair from tanneries, oil-cakes.

5 to 2 per cent. Flesh, poudrette, bone meal, blood, refuse from breweries.

2 to 1 per cent. Soot, fish, pea straw.

1 to 1-2 per cent. Water from gas works, urine, dung of sheep, swine, men, horses, turf, leaves, stable manure, bone coal, phosphatic guano, vegetable mould, sediments from sugar refineries, herring brine.

1-2 to 1-10 per cent. Excrement of horned cattle, grain, straw, oyster shells, saw dust, drippings from manure heaps.

(2.) *Phosphatic Manures.*

PHOSPHATIC GUANOS.—The Peruvian guano owes its high per centage of nitrogenous matter to the circumstance that it has been accumulated in a rainless region. Of essentially different composition are those varieties of guano that have been accumulated in regions where rain falls, for there the excrement of the birds rapidly undergoes decomposition, and the soluble nitrogenous matters thus produced are subject to constant leaching out by the rains, so that an accumulation of nitrogenous and potash compounds is rendered impossible.

Where these deposits lie upon limestones, the conditions are favorable to the formation of lime phosphate, which is comparatively insoluble. Such phosphatic guanos are sometimes stony, sometimes soft and pulverulent, and mixed with lumps which are similar to the ordinary Peruvian guano. The color is white to chocolate brown, and they are odorless, or, at most, possess a faint smell.

Among the most important of these phosphate guanos are the Baker, Mexillones, and Raza guanos, the first two from the coast of Bolivia, also called Columbian guanos. The West Indian guanos are the Curacoa, the Sombrero, and the Navassa.

Guanos of this kind from the African coast are considered less valuable.

The Baker and Sombrero guanos have the following compositions:*

	Baker Guano.	Sombrero Guano.
Nitrogen	0.3— 1.0	....—....
Phosphoric acid	37.0—40.3	32.5—39.6
Lime	39.1—43.5	27.7—51.7
Ash	80.0—89.7	85.0—90.0

* Mayer, Agrikultur Chemie, I, p. 259.

From this it will be seen that these guanos are essentially phosphates of lime. Before use as manure, it is in all cases necessary to treat them with sulphuric acid for the purpose of converting the phosphate into super-phosphate, as is done also in the case of bones. Many of the high grade super-phosphates, containing 20 per cent. and upwards of soluble phosphoric acid, are manufactured from Baker and Sombrero guanos.

The Sombrero and Navassa guanos form a transition to the mineral phosphates, in which the organic origin is no longer apparent, except in some few cases, where a remnant of carbon colors the phosphate black.* The more important mineral phosphates are given below.

MINERAL PHOSPHATES.—*Apatite*, a phosphate of lime, is an ingredient of many crystalline rocks; when it occurs in large masses it is called *phosphorite*, and when somewhat pulverulent *osteolite*. Deposits of this substance are found in Norway, Canada, Spain, Bavaria, and other countries, and lime phosphate in small quantities is a constituent of many volcanic rocks.

Coprolites are masses of phosphate of lime derived from the excrement of extinct animals, and are found in considerable quantities in England, Bohemia, France, etc. They vary greatly in composition, and contain usually a good deal of iron oxide and alumina. They are used in the manufacture of low grade super-phosphates, but not directly on the field in the form of powder.

Phosphate Rock of South Carolina.—Beneath the soils and river alluvium of certain parts of South Carolina, near Charleston, a stratum, averaging perhaps fifteen to eighteen inches in thickness, and containing from 50 to 67 per cent. of Phosphate of Lime, is very extensively worked and used in the manufacture of super-phosphates and other artificial fertilizers. The origin of this phosphate rock is by some thought to be from the action of the fecal matters of extinct land quadrupeds upon beds of carbonate of lime, just as the Baker guano is due to a similar reaction of the excrement of birds upon limestones.†

* Hoffmann- Gohren, Agrikultur Chemie, p. 464.

† Holmes, Phosphate Rocks of S. C., p. 39.

This rock is mined and manufactured into fertilizers by a number of companies, of which the following are among the best known: Charleston, Wando, Etiwah, Oak Point, Marine and River, Carolina, Chicora, Atlantic, Stono, Farmer's Palmetto, Pacific, Wappoo.

Phosphate Rock of Florida.—Near Hawthorne, Alachua county, Florida, a light-colored, soft rock, which was quarried for building purposes, was discovered by Dr. George W. Hawes, of the National Museum, to contain a large per centage (16) of phosphoric acid, and will no doubt in time be worked out for the sake of this material. (For analysis of this rock, see Census Report on Cotton Production in Florida, by Eugene A. Smith, p. 14.)

There is good reason for thinking that a similar phosphatic rock will yet be found in Alabama, a part of whose Tertiary rocks are analogous to those of Florida in which this substance occurs.

BONES.—The bones of animals consist one-third of animal matter, cartilage, etc., and two-thirds of mineral matter, the greater part of which is phosphate of lime, and about six to seven per cent. carbonate of lime, and are used as fertilizers because of the phosphate of lime which they contain, averaging about 60 per cent. of their dry weight.

For fertilizing purposes, bones are used in several ways. In the first place, they are simply ground up and thus left to the influences of the atmospheric agencies to convert their nitrogen and phosphoric acid into easily assimilable forms. The finer the powder, the more rapidly efficacious the action of the bone meal.

In order to obtain the bones in a still finer state of division, it is customary to subject them first to the action of super-heated steam, by which they are deprived of a part of the cartilaginous matter, and, after drying, become very much more brittle and easily reduced to powder. By this process, the content of nitrogen is somewhat diminished, but the powder is more efficacious because of the finer division of which the steamed bones are capable, and also because of the greater susceptibility to decomposition to which the organic matter is brought by the action of the steam.

SUPER-PHOSPHATES.—For the purpose of making the phosphoric acid more available to plants, bones and other phosphates are treated with strong acids, chiefly sulphuric and hydrochloric, which convert the basic or bone phosphate of lime into the acid or super-phosphate, producing at the same time chloride or sulphate of calcium, according to the acid used. The gypsum or sulphate of calcium (lime) is much more beneficial to the soil than the chloride, and for this reason sulphuric acid is much more commonly used in the manufacture of the super-phosphates.

Other methods of converting the bone phosphate into super-phosphate are, the fermentation of the bone dust with urine or the drainings of the manure pile; treatment with caustic alkalies, etc.; and recently it has been shown that fermenting cotton seed convert bone dust into super-phosphate. (See above, under Nitrogenous Manures.) Instead of ground bone, bone ash, bone coal, etc., are sometimes used in the manufacture, but in these two forms, the whole of the nitrogen is lost, and the product is valuable solely on account of its content of phosphoric acid.

Action of Super-phosphates; Reduced or Reverted Phosphoric Acid.—The super-phosphate is soluble in water, while the ordinary bone phosphate is not. When applied to the soil, the super-phosphate is dissolved by the rains, and thus more or less evenly disseminated through the soil. But in contact with the constituents of a normal soil, it is speedily carried back into the basic or insoluble form.

The advantage, therefore, of using the soluble form is not that the phosphoric acid is presented to the roots of the plant in solution, but that when brought into the insoluble form by the chemical action of the soil itself, it is in an infinitely finer state of division, and correspondingly more available to the plant, than in the finest powder attainable by merely mechanical means, and in addition, some at least of the compounds formed by the phosphoric acid with the constituents of the soil, are more easily soluble, and on this account also more assimilable than the bone phosphate.

Many samples of super-phosphates contain, in addition to the phosphoric acid soluble in water, a certain percentage

of *reduced* or *reverted phosphoric acid, i. e.*, phosphoric acid, which, after having been rendered soluble by the action of sulphuric acid, has combined with iron, alumina, or lime to form a phosphate which is no longer soluble in water, but yet quite soluble in dilute acids. These constituents are present in many kinds of super-phosphates, and consequently a portion of their phosphoric is in the reduced or reverted form.

By many chemists the reverted acid is considered nearly, if not quite, as available to the plant as the soluble, and the value of the manure is estimated from the percentage of phosphoric acid in both forms.

With an excess of lime there is the tendency to form still less soluble compounds, and hence the mixture of lime with the super-phosphates is to be avoided.

The action of the super-phosphates is due not only to the phosphoric acid, which is a nutritive substance, and a true plant-food, but also to the sulphate of lime or gypsum, which is always produced in large proportion in the manufacture. The action of gypsum, as we shall presently see, is strongly stimulating.

The exclusive use of super-phosphates will, in the end, exhaust land of those ingredients of plant-food which the manure itself does not possess, namely, potash, and to some extent also, nitrogen. To supply these deficiencies, other substances are added to the super-phosphate, such as ammoniacal salts from gas works, greensand, and sometimes also the potash salts from the German mines. Such mixtures may contain all the mineral elements of plant-food.

PRECIPITATED PHOSPHATE OF LIME.—This substance is a bye-product in the manufacture of glue, and consists of the basic phosphate of lime. It is therefore of same composition as ground bone; but in some manufactures the much more soluble neutral phosphate is produced, containing from 35 to 42 per cent. of phosphoric acid, in a form in which it is readily assimilable by the plant.

The phosphates are applied with great advantage to pastures, and those crops which are cultivated for the roots or tubers, such as turnips, etc.

(3.) *Potash Manures.*

The concentrated potash manures are all, without exception, of purely mineral origin, for ashes and similar organic materials do not contain such a preponderance of potash as to be ranked as specific potash manures.

POTASH SALTS.—Since 1858 a number of salts of potash have been exported from the salt mines at Stassfurth in Germany, where they form the upper covering of the rock salt deposit. The most important of these salts is *Kainite*, which is double sulphate of potash and magnesia, containing from 15 to 18 per cent. of potash. In addition to this and a number of other naturally occurring salts of potash, many preparations containing a much higher percentage of potash, are made by concentrating the crude salts.

ASHES.—The ashes of wood contain the highest percentages of potash, about five, and about three of phosphoric acid; ashes of turf or peat contain less; and those of mineral or stone coal almost none. The leached ashes of the soap maker, though deprived of potash, still contain the phosphoric acid, and are on this account valuable.

ORGANIC REFUSE.—A great variety of organic refuse matters, such as oil cake, waste from sugar manufactories, etc., contain small percentages of potash and may be used as sources of this element.

Potash minerals, such as feldspar, etc., have by their disintegration furnished the potash contained in the ordinary soils, and propositions have been made to use such minerals powdered up, as a source of potash for agricultural purposes, but no profitable method is yet known.

ACTION OF POTASH MANURES.—The Stassfurth potash salts act both *directly*, because of their content of potash, and *indirectly*, because of the admixture of other substances, such as salts of magnesia and soda, by which they are usually accompanied.

Potash enters into the composition of most crops, and especially of root crops, yet experiments made with special potash manures, have shown that their action depends very

largely upon the character of the soil, the weather, the manner of applying, and the kind of the crop, and the results in consequence, have not always been equal to the expectations. In general, potash acts favorably upon sandy soils and those which have comparatively little absorbing power, while the heavier soils are likely to be deficient rather in some of the other elements of plant food, than in potash.

Whether or not an application of potash will be profitable, can probably be told with certainty only by comparative experiments.

Potash manures are seldom used alone, but mostly in composts with other materials, among which lime has often been found advantageous, as also gypsum.

It was remarked above that most of the partial nutritive manures, contain other elements of plant food besides that upon which their specific action depends. The following table, taken from Wolff (Praktische Duengerlehre), shows the chiefly active constituent or constituents of the nutritive manures above named:

(1). *Nitrogen:* Chili saltpetre, salts of ammonia, woolen rags, desiccated flesh, horn, hair from tanneries, soot of bituminous coal, dried blood.

(2). *Phosphoric acid:* Baker guano, Mexillones guano, bone coal, apatite, phosphorite, bone ash and the super-phosphates derived from it, phosphate of lime from glue and other technical works.

(3). *Potash:* Potashes, Stassfurth potash salts, soap boilers' refuse, refuse from tartaric acid works, Greensand.

(4). *Nitrogen predominant, Phosphoric acid subordinate:* Peruvian guano, fish guano, oil-cake, manures prepared from blood, urates.

(5). *Phosphoric acid predominant, Nitrogen subordinate:* Bone meal steamed or treated with sulphuric acid, Fray-Bentos- guano, ammoniated super-phosphates, poudrette.

(6). *Potash and Phosphoric acid:* Wood ashes, potash super-phosphates.

(7). *Potash and Nitrogen:* Drainings from manure pile, Potash saltpetre.

B. Indirectly Acting or Stimulant.

Under this head are included all those substances which are incapable of *directly nourishing* plants, but which by their presence in the ground cause an increase in the production.

Strictly speaking, all those substances which increase the fertility, either by modifying the physical condition of the soil, or by reason of the products arising from their chemical decomposition in the soil, in so far as these decomposition products are not actually nutritive salts, should be classed with the indirectly acting manures.

ACTION OF STIMULANT MANURES.—The chief causes of the efficacy of indirectly acting manures have been given by Mayer, as follows:*

This action consists—*a*, in bringing insoluble substances into solution, in which form they are rendered more available to the plant; *b*, in the production in the soil of several other useful reactions of varied nature; and *c*, in their direct influence upon the absorption of dissolved salts by the plant.

(*a*). The insoluble plant food may be brought into solution by the direct solvent action of some of the constituents of the manure; thus, carbonic acid has a solvent effect upon silicates and phosphates; and to a similar solvent power, may be ascribed a part of the action of the nitrates and of the compounds of ammonia.

(*b*). Another, and far more efficient way of converting the insoluble plant-food into soluble form, may be made clear by a review of some of the phenomena of absorption already spoken of. As the result of a great number of experiments in absorption, it has been established that the fixation of substances absorbed by the soil, is *neither complete nor permanent*, and that by means of large quantities of water they may in some measure be again washed out of the soil; and if instead of pure water, strong solutions of other bases be used, the quantity of the absorbed substances removable from the soil by such solutions is very materially increased. It follows from this that any base that has been absorbed by the soil can be removed therefrom partly, or entirely, by any other base, which is absorbed in its stead. To illustrate: if a soil be acted on by solution of a potash salt, the latter, or a part of it, will be absorbed, or become partially insoluble, and for every equivalent of potash absorbed an equivalent portion of some other base previously in the soil will be released.

Now, if a large quantity of a solution containing lime be added to the soil thus charged with potash, the very reverse reaction will take place; namely, a part of the potash will be released, and in its stead a portion of lime will be retained in the soil. A similar reaction takes place whenever an ordinary manure is applied to a soil containing certain bases in a state of absorption. And thus an application of lime, for instance, becomes in reality equivalent to a manuring with potash, ammonia, etc., inasmuch as these bases (present in the soil, but in insoluble form,) are set free by its means.

*Agrikultur Chemie, II, p. 280.

(*c*). Another useful reaction produced in the soil by certain manures, depends upon their power of removing or transposing the absorbed plant-food from one layer of the soil to another. Under ordinary circumstances, when a nutritve manure is applied to the soil, its stock of plant-food is mostly absorbed or fixed in the upper portion of the soil, and is of course of use to those plants only whose roots spread in that particular layer. Now when a manure, such as lime, is added, the soluble salts of lime fill the upper layers of the soil, setting free the nutritive salts previously absorbed there, and these then sink to the deeper strata before being again fixed by absorption.

The consequences of this to those plants with deeply penetrating roots can easily be seen. The efficacy of certain classes of manures has been ascribed to this action.

(*d*). And lastly, as the result of a number of experiments upon the conditions affecting the absorption of nutriment by plants, it has been shown that the assimilation of any mineral constituent can be greatly increased by the presence in the soil at the same time, of some other nutritive salt.

This peculiarity cannot fail to be of importance in connection with the action of many manures.

With these general principles in mind the explanation of the mode of operation of certain indirectly acting manures will be more easily understood.

(1.) *Carbonaceous Manures.*

HUMUS.—For a long time this substance was thought to be a direct nutriment of plants, and only after closer study was the real cause of its action revealed as being due to the changes produced by it in the physical structure of the soil, and especially to the plant-food set free and rendered available during the process of its decay. The significance of humus as a soil-constituent has already been spoken of at length and need not be repeated here.

(2.) *Calcareous Manures.*

GYPSUM.—Gypsum is composed of two substances, both of which serve as direct nutriment of plants, viz., sulphuric acid and lime, and a part at least, of its manuring effect may be ascribed to this, which is, however, not the sole cause, since it brings about good results even when the soil is by no means deficient either in lime or sulphuric acid. A perfectly satisfactory explanation of the action of gypsum seems not yet to have been given.

Liebig and his followers considered the manuring force of gypsum to be chiefly owing to its power of absorbing and fixing the volatile salts of am-

monia, and its usefulness in this respect cannot be denied, especially when it is used in composting with stable manure, etc.; but since the soil already contains constituents which are competent to absorb all the ammonia salts which are washed into it by rain. etc., the adequacy of this theory has been called in question.

Another explanation is based upon the principles set forth above. Gypsum is a soluble salt of lime, and when applied to the soil the lime replaces the absorbed bases, which, in so far as they are nutritive substances, are thus placed at the disposal of the plants. In this way an application of gypsum acts like manuring with potash, etc. And still further, the potash or other nutritive element thus released is distributed in solution to other strata of the soil than those in which it was first absorbed, and may thus be brought within reach of deeply penetrating roots. And another possible cause of the efficacy of gypsum, may be found in the circumstance, well established by experiment, that the presence of gypsum, as well as of nitrate of lime, causes potash salts to be more readily assimilated by the roots of plants.

Heiden* has spoken of still another respect in which gypsum may exert a favorable action upon the growth of plants, based upon the circumstance, that by a concentration of the soil fluids, the transpiration of moisture through the leaves of plants is diminished, so that an application of gypsum will enable a crop to withstand longer the effects of drouth.

So much for the theories which have been advanced as to the mode of action of gypsum. Practical experience has shown that gypsum benefits only those soils which are in moderately good condition, and not those that have been worn out, probably because of the absence of those elements of plant-food in absorbed state, which it is capable of bringing into solution in the manner above described. Gypsum produces its best effects when used as manures for deep-rooted plants, probably because by its action the absorbed plant-food is removed from the upper to the lower layers of the soil. The facts that gypsum is a special manure for pease and other leguminous plants, while it is useless for cereals, are not so readily explained by any of the theories advanced. The effects of gypsum are best secured upon moderately deep, warm soils, with plenty of vegetable matter, and in moist and warm seasons, and in many respects, it is more profitable to use it in connection with stable manure than alone.

Gypsum occurs naturally in deposits of considerable extent, from which it is mined and used without further preparation except grinding to powder; or else it is first burned,

*Duengor-lehre, II. p. 449.

by which the combined water is driven off, increasing the realative percentage of the effective portion. Sulphate of lime is a bye-product of many technical works, and as we have already seen, a constituent of all super-phosphates.

The gypsum deposits of the Tertiary formations of Alabama have been described in the special part of this report, and it is to be wished that the attention of farmers be turned to the great benefits to be derived from the proper use of this material.

QUICK LIME; CARBONATE OF LIME; MARL.—The action of all these substances is the same, and they may therefore be treated together. Quick lime, when brought upon the soil is very speedily converted into the carbonate by the action of the carbonic acid of the atmosphere, and the main advantage in its use is the fine state of pulverization which it takes on in the course of slaking, by reason of which its uniform distribution over the land is more easily secured.

Lime increases the fertility of the soil by indirect means chiefly, for it does no good upon land which has not already a sufficiency of plant food, and it increases the yield without at the same time increasing the amount of lime salts in the crop. But on the other hand, it is a necessary constituent of all plants; most soils, however, contain sufficient lime for the actual needs of plants in this respect.

EFFECTS OF LIME.—The principal effects of lime upon soils may be summed up as follows: *Caustic lime* has the power of greatly accelerating the decomposition, both of mineral and of vegetable matters, and applied to the soil, it brings about those changes in a comparatively short period which, in the natural course of events, would extend over several years. It is thus seen to be a strong stimulant, rapidly draining the soil, by increasing the availability of its stock of plant food. And like gypsum it acts by introducing into the soil, a soluble salt of lime which displaces and brings into solution other absorbed salts of the soil, and causes their more perfect distribution in its different layers.

Lime is also beneficial in keeping down the growth of a variety of weeds, by stimulating the cultivated crop. It has, further, the effect of improving the physical qualities of

heavy clay soils, making them more porous, and less liable to work up into a plastic mass when wet.

One of the most important qualities of lime, from an agricultural standpoint, however, is found in its action upon vegetable matter. This organic matter in the soil is of advantage chiefly because the products of its decay, carbonic acid and nitrogenous compounds, are important constituents of plant-food, and at the same time act energetically upon the still undecomposed mineral constituents of the soil, breaking them down and rendering available their content of plant-food. Lime promotes the rapid decay of vegetable matter and its conversion into humus, the presence of which in the soil is usually indicated by the dark or black color. The prevalence of this dark color in limy soils which have a sufficient supply of vegetable matter, has no doubt been observed by every one.

The explanation of this rapid action of lime may be found in the circumstance that the *humates*, *i. e.*, the compounds of a humic acid with the bases, are, in presence of moisture, more easily oxidized than are the humus substances alone.

Lime is, of all the bases, that one which is to be had in greatest quantity and at lowest price, and is moreover less caustic in its action upon tender plants than other bases which might exert a similar action upon vegetable matter.

A certain amount of humus is a constituent of every good soil, and when the use of lime by too greatly accelerating its decay would reduce it too much, it is to be avoided.

Soils which contain a sufficient quantity of humus are, on account of their dark color, readily warmed by the sun's rays, and this is a great advantage in cool climates; and soils rich in humus are at the same time the best absorbers and retainers of moisture, which in dry localities is of advantage to the plants growing upon the soils; and further, vegetable matter loosens and improves heavy clay soils.

Too great a proportion of humus, on the other hand, is a disadvantage, and in moist climates it is the cause of excessive wetness of the soil. In such cases all the pores of the soil are permanently filled with water to the exclusion of air, the decay of the vegetable matter is retarded, and takes on a form which results in the production of the so-called "sour humus," which is so unfriendly to all cultivated plants. Lime is one of the best materials for correcting this acidity, and in connection with proper drainage hastens the decay of the excess of organic matter, and thus contributes no little to the conversion of a useless bog into a fertile field. The analyses of Dr. Hilgard have shown that sour soils are deficient in lime, lacking even the small percentage required fully to supply the needs of plants as nutriment.

In those sections whose soils are generally deficient in lime, the humus substances contained in the soils pass into solution, imparting to the waters

of creeks, and branches, a coffee-brown color. This may be noticed in many places in the southern counties of the State, and even in some parts of central Alabama, especially in the piny woods. The presence even of small quantities of lime renders these humus bodies insoluble in water, hence the remarkable clearness of the water of limestone springs.

A soil permanently charged with water is liable to another evil, namely, the formation of the *ferrous salts*, which are so injurious to all forms of vegetable life. Through the agency of lime, such salts are decomposed, with the formation of sulphate of lime and ferrous hydrate, which is highly oxidizable and passes rapidly into ferric hydrate, a useful ingredient of a cultivated soil.

Lime has also apparently the effect of causing the soil to absorb and retain for the use of certain classes of plants, soluble silica, which soils very rich in humus seem to be incapable of doing.*

It is a matter of observation that lime does not remain permanently in the soil, but is washed out by rains. In consequence of this, soils which have been derived from disintegration of limestones contain often less than one per cent. of lime. The lime which has been applied as manure, also sinks into the soil and often accumulates in a layer several inches below the surface.

To attain the same ends as are accomplished by the use of quick lime or carbonate of lime, *marls* have long been in use in many countries. Strictly speaking, a marl is a calcareous clay, but the name has often been extended so as to include also calcareous sands, shell deposits, and the like. The application of marl has therefore sometimes the effect of producing a mixture of soils, and from this point of view, may cause a desirable change in the physical qualities of the soil, as when a clay marl is spread upon a sandy soil, or a sandy marl upon a heavy clay soil. In addition to this, marls have often notable quantities of some of the elements of plant food, which are not only added to the soil upon its application, but these nutritive elements of the marl, from the action of the lime from time immemorial, are in a condition at once to be appropriated by the plant. This will explain why the addition of marl may sometimes prove beneficial even when there is no deficiency of lime in the

*Hilgard, Geology of Mississippi, p. 229.

soil, and when it contains a relatively larger percentage of nutritive elements than does the marl itself.*

From what has been said it will be seen that marling can by no means be looked upon as a substitute for other manures, but that it makes a soil momentarily richer, or rather, more productive, but at the same time hungrier; and only permanently fertile, when this hunger is regularly satisfied by the addition of nutritive manures.†

In the case of marls which contain a large percentage of other substances besides the lime, an overdose is not easily effected, but it is very different with pure lime.

From the chief mode of action of lime as above explained, it will be seen that it has the effect mainly of rendering quickly available the nutritive matter already contained in the soil, and hence the frequency of application, and the quantity to be used, will depend mainly upon the quality of the soil. If this is naturally strong and contains much vegetable matter, a heavy dressing of marl repeated every few years will not be out of place, especially if compost or stable manures be used in connection with it.

In the special part of this Report, I have given a tolerably full account, accompanied by analyses, of the various marls occurring in the Tertiary formations of Alabama.

(3.) *Saline Manures.*

COMMON SALT.—For the great majority of plants, neither chlorine nor sodium can serve as nutriment, and it therefore follows that any benefit derived from the application of salt as a manure must arise from its indirect action.

A solution of salt applied to a soil which has other bases absorbed, will, in the manner already explained above, set free these bases (lime, magnesia and potash), while an equivalent proportion of sodium will be absorbed in their place. In this way, the soil may be enriched by the nutritive elements thus brought into solution, and rendered more available.

By direct experiment, it has been shown that a solution of salt has the power of extracting from a soil a much larger proportion of its absorbed

*Hilgard, Geology of Mississippi, p. 230.

†Mayer, Agrikultur Chemie, II, p. 293.

bases than has pure water, so that there can be no doubt of its efficacy in this respect. Other experiments have proven that manuring with salt alone, in many cases, very materially increases the yield of a field; but on the other hand, there are not wanting experiences which show directly the contrary.

It has been said already that many chlorine compounds, and especially those of magnesia and lime, are directly injurious to vegetable life; and if the conditions are present in the soil for the formation of such compounds by the use of salt, it may easily happen that the favorable action above mentioned may be entirely neutralized, and even outweighed by the evils arising from the formation of the chlorides named.

These general principles will serve to explain the great variety of opinion existing as to the expediency of using salt as manure. Numerous field experiments have shown that greater yields are usually obtained by using salt in connection with ammonia salts and nitrates, than by using these nitrogenous manures alone. A satisfactory explanation of this has not been given.*

OTHER SALTS.—A part of the action of the nitrates of soda and potash, already spoken of as nutritive manures, is also indirect and analogous to that of common salt.

GENERAL PRINCIPLES GOVERNING THE USE OF MANURES.

It is almost self-evident that the permanent maintenance of the fertility of the soil involves the complete restoration to it of all those ingredients withdrawn in the removal of crops. But *when* and *how* this return is to be made are questions which deeply concern every one who is dependent upon the products of the soil for his support.

It has been said that "the true economical principle of manuring is to supply the soil with the element or elements in which it is relatively deficient, in respect of the requirements of the crop it is intended to grow."

To add potash, for instance, to a soil which has already

*Mayer, Agrikultur Chemie, II, p. 297.

enough of that element to meet the wants of a growing crop, is practically to waste it.

It would appear to be a comparatively easy matter, knowing the chemical composition of a crop, and of the soil upon which it was to be cultivated, to prepare a manure which would exactly meet the demands made upon it; yet experience has shown that while plants of necessity require for their growth *all* the ingredients which enter into their composition, different families of plants have very different capacities for appropriating the plant-food actually presented to them.

A knowledge, therefore, of the requirements of the various cultivated crops can only be obtained by a close and careful study of their behavior under varying conditions.

Messrs. Lawes and Gilbert, of Rothamsted, have conducted for many years a series of field experiments with different crops, some of the results of which I shall briefly present here. The experiments proved that while the *cereals* are the least nitrogenous of all the crops, they stand in most need of artificial supplies of nitrogen, and analyses of the soils from fields in which wheat yielded a very poor crop still showed the presence of considerable quantities of nitrogen.

The cereals, therefore, compared with other crops, have very *little power of assimilating nitrogen*, and can make use of only a part of that actually supplied to them in manure, the rest being either fixed in the soil or washed out by rains into the drain water and thence into the sea, where it may serve to support various forms of marine life, while temporarily at least lost to land plants; and on account of the great solubility of nitrogenous manures, they should be applied only when the plant is at a stage to appropriate them at once.

The *leguminous* plants, such as clover, beans, etc., on the other hand, contain a large amount of nitrogen; yet they are well able to supply themselves with this element from soils incapable of producing a good crop of wheat without addition of nitrogenous manures. Application of *nitrogenous* manures produced no effect upon the bean and clover crops, while addition of *potassium* salts produced the greatest yield. The experiments further showed that upon some lands it became impossible after a time to produce good crops of leguminous plants, even with large quantities of every kind of manure.

Experiments with *root crops*, such as turnips, showed that these, while containing a large proportion of potash, are comparatively little benefited by manures containing this element, as they appear to be amply able to supply themselves with what they need of potash from almost any moderately good soil.

The best returns were had from the application of *phosphates*, especially when mixed with *nitrogenous* manures. Another point brought out in these experiments was that the proportion of leaf to the root was greatly increased

with increase of the quantity of nitrogen in the manure. The turnip has its weakest point in its inability to appropriate the phosphoric acid of the soil, and as soon as the soil becomes partially exhausted, nitrogenous manures produce little effect, unless phosphates are also added; but on the other hand, turnips, like the leguminous plants, have great power of appropriating the nitrogen of the soil.

Beet roots are like the turnips, comparatively indifferent to the alkaline manures, but unlike them, are capable of supplying themselves from the soil with what they need of phosphoric acid, and are generally benefited by the addition of nitrogenous manures to the soil.

In the nature and quantity of the residues left after the harvest, crops differ very widely from each other. Turnips and beets leave very little, as their rootlets are small, while clover and beans, with their deeply penetrating roots, leave large residues which may be of great value to the succeeding crop. Leguminous plants are hence generally considered to be of great service in bringing up from the subsoil large quantities of plant-food, and leaving it in the top soil where it may be utilized by some other crop. The amount of nitrogen which these plants are capable of assimilating, as has been seen above, is so great as to lead to the belief in some quarters that they are capable of appropriating this element directly from the atmosphere—a conclusion called in question, however, by the majority of chemists.

The experiments at Rothamsted and elsewhere have further made it clear that in order to produce a certain increase in the crop, the quantity of manure used must be greatly in excess of the amount which can be assimilated by the crop, since it is impossible that all the manure employed should come in contact with the roots of the plants. The least waste is experienced when the manure is used in the liquid form or applied in the state of fine powder, or else when the manure is strewn in drills so as to concentrate it near the seed.*

That part of the manure, with the exception of the nitrogen, which is in excess of the requirements of the present crop, will be accumulated in the soil for the benefit of some succeeding crop, at the same time improving the general condition of the land. In order not to waste the manure, or let it lie too long without returns, special manuring to

*Encyclopædia of Chemistry, Article "Manure."

meet the special requirements of each particular crop, is of course the system which most commends itself. And to apply this principle intelligibly, the characters of the particular field, as well as of the particular crop, must be studied. This knowledge can best be gained by field experiments on a small scale, which any farmer may carry out, and from which he may learn with certainty whether or not a certain application of manure will be profitable on his own land.

Means of Estimating the Value of a Soil.

The practical value of all our knowledge of the origin and formation of soils, of their physical and chemical properties, and of their varied relations to the vegetable world, lies in its application in forming a correct estimate of the value of soils for agricultural purposes; in ascertaining their natural capabilities and deficiencies, and in suggesting the means by which their productiveness may be increased.

To the farmer, a soil is valuable in proportion to its capacity for producing with the least outlay of money or labor, an amount of vegetable matter which may be used as food, or otherwise turned to account; and in estimating its worth, regard must be had to all the conditions which in any way influence the fertility of the soil, and the realization of profit upon its productions.

Conditions of Fertility.—The circumstances which affect the soil's capacity in these respects, are either external to it, or they reside within it.

1. The external conditions are climate and the inclination or slope of the ground. The climate depends upon the latitude, the elevation above the sea, the topography, the proximity to the sea or to other bodies of water, the annual rainfall, etc. These, so far as Alabama is concerned, have been spoken of in some detail, further on in the Special part of this Report. The slope of the field is plainly of importance, for with an angle greater than 20 degrees, cultivation becomes difficult, and with much greater angles, impossible.

2. The internal conditions which determine the productiveness of a soil, are its physical properties, and its chemical composition.

It can obviously form no part of the plan of the present report to give in detail any of the various methods which have been proposed and practiced with a view to investigate the qualities of the soil, except in so far as may be needed to enable the reader to interpret for himself much of the work presented in the sequel.

METHODS OF SOIL INVESTIGATION.—The usual methods of soil investigation belong to the following classes: 1. Determination of its physical properties; 2. Mechanical Analysis; 3. Chemical Analysis; 4. Inferences from its actual productions, either natural or under artificial conditions.

(1) *Determination of Physical Properties.*—Many of the physical qualities of soils are approximately learned by careful observation, and without any experimental tests. Where, however, accurate information is required, special tests are made to determine the *specific gravity*, the *permeability*, the *retentiveness* of *moisture*, the *capacity for condensing moisture from the atmosphere*, the *capillary power*, *absorption* and *retention* of *heat*, *porosity*, *closeness*, *adhesiveness*, etc., by methods which are fully described in most text books of Agricultural Chemistry.

Of these special tests, only one has been made use of in the soil investigations with which this report is concerned, viz: that of the *hygroscopic moisture*. This is determined by exposing for at least twenty-four hours, to an atmosphere saturated with moisture, a thin layer of the finer portion of the soil, and expelling the moisture thus absorbed by heat which does not exceed 400 degrees of Fahrenheit. From the loss in weight thus produced, the percentage of moisture absorbed may then be reckoned. These determinations have been made for all the soils whose analyses appear in the Second part of this Report.

(2) *Mechanical Analysis.*—We have seen above, that those qualities which fit a soil to give support to the plant, and to act as a store-house of plant-food, and to serve it out as needed, are determined in great measure by the relative proportion, and the mechanical condition, of the predominating constituent, whether it be humus, clay, sand, or lime.

To separate a soil into its constituent parts is to gain important knowledge as to its fitness as a bearer of vegetable life; "is," to use the words of Knop, "to a certain extent to make it transparent." This separation is effected by means of mechanical analysis.

To this end the soil sample is brought upon a sieve with meshes three millimetres in diameter; all that passes through, is called the *fine-earth*, that which remains is the *framework*, which is still further divided by means of sieves with meshes of varying size, into gravel, etc., each of which is examined as to its composition, *i. e.*, whether it consists of fragments of minerals or rocks capable of still further decomposition and thus of serving as a reserve of plant-food, or of fragments no longer capable of alteration. The fine-earth is then usually separated by means of some form of elutriating apparatus into grits, sand, fine sand, silt, and clay. In this apparatus the separation is made by flowing water usually, the sediments of different kinds coming to rest in positions determined by their relative sizes. It is obviously of great importance to know, also, the chemical and mineralogical composition of the coarser and of the finer portions of the soil. The quality of the former can generally be determined by simple inspection and a few chemical tests, while a more careful and detailed examination is needed to give definite information respecting the composition of the fine-earth.

In Knop's method of examination of the fine-earth, determinations are made of the percentages of hygroscopic and combined moisture, and humus; of the sulphates, carbonates, and silicates, and of the character of these silicates; and lastly, an estimate is made of the soil's absorptive power for salts of ammonia. His method, therefore, while it does not give the ultimate chemical composition of the fine-earth, still estimates those proximate constituents upon which the most important qualities of the soil depend.

The parts borne by the several constituents of the soil have already been spoken of above, and knowing the relative proportion of each in a soil, much may be inferred concerning its fitness in various respects as a supporter of vegetation.

(3.) *Chemical Analysis.*—A fertile soil must of necessity contain not only an *amount of plant food sufficient* for the needs of the plants, but this food must be in an *assimilable form.* It is universally admitted that an *ultimate* analysis of the soil can be of no use as indicating its immediate fertility. Such an analysis gives the total amount of plant-food but says nothing concerning its availability. "Many attempts have been made to find solvents whose action on soils would so nearly represent the agents subservient to the needs of vegetation, that conclusions as to the present agricultural value of a given soil could be deduced therefrom. From fluohydric acid, to water charged with carbonic acid, the

acid solvents have all signally failed to secure even an approximation to the result desired, viz., a consistent agreement between the quantitative determination, or the percentages of plant-food, found in the several soils, and the actual experience of those who cultivate them."*

In view of these failures the majority of chemists seem to have reached the conclusion that the chemical analysis of soils can lead to no useful result. The investigations of Dr. Hilgard upon the soils of Mississippi, and recently also upon those of other Southern States, (in connection with Census Reports,) have, however, shown that chemical analysis of soils, taken in connection with their physical examination, is capable of yielding very important results when properly interpreted. The following summary of the results of these investigations, is here presented, in order that the teachings of the soil analyses given in another part of this Report may be understood, and appreciated by the reader.

The fundamental principle in these investigations is thus stated: "Taking for granted the soundness of the old farmer's judgment of the productiveness of a soil from its natural vegetation, I have sought to determine, by close chemical and physical examination of the soils in their natural condition, the causes that determine this natural selection on the part of certain species of trees and herbaceous plants; while, at the same time, observing closely the behavior of such soils under cultivation, their special adaptations, etc."

"It is evident that when used in this connection, and made uniformly and systematically, with a definite problem in view, each soil analysis becomes an equation of condition; and that by the proper treatment of a large number of such, by logical process of elimination, the problem of the function and value of each soil-ingredient or soil-condition can be approached with better prospect of a solution in accordance with *natural* conditions, than can be expected from cultures upon artificial soil or in solutions."

The first important step is the taking of representative

*This, and the other citations which follow, are from a paper by Dr. E. W. Hilgard, On the Objects and Interpretation of Soil Analyses; American Journal of Science, III, Vol. 22, p. 183 & f.

samples of the soil, and to this end printed directions are given, by which certain data are secured, viz., proper selection of the localities, discrimination between the soil and subsoil, a record of the depth, natural vegetation, behavior in cultivation, etc., and with proper care it is possible to obtain samples representing typically, soil areas of many thousand square miles; especially when the subsoils are taken as the more reliable indices.

The soil sample is prepared for analysis by breaking up the lumps, and separating all the larger fragments of minerals, vegetation, etc., from the fine-earth, which is then digested for five days in hot, strong, hydrochloric acid, and the extract from this digestion, then analyzed by the best methods with every precaution taken to secure accuracy in the results.

"In the selection of the *solvent for making the soil-extract* to be analyzed, I have been guided by the consideration, that minerals not sensibly attacked by several days' hot digestion with strong hydrochloric acid, are not likely to furnish anything of importance to *agriculture*, within a generation or two."

"*Interpretation of the analytical results.*—Having obtained, as above outlined, the percentage composition of a soil, how are we to interpret these percentages to the farmer? what are 'high' and 'low' percentages of each ingredient important to the plant, whether as food or through its physical properties?"

"The first question arising in this connection, is naturally, whether all soils, having what experience proves to be high percentages of plant-food when analyzed by the processes above given, show a high degree of productiveness?"

"So far as my experience goes, this question can, for virgin soils, be unqualifiedly answered in the affirmative; *provided* only, that improper physical conditions do not interfere with the welfare of the plant."

"But it does not, therefore, follow, as was at first supposed, that the converse is true, and that low percentage necessarily indicates low production;" for so long as in some soils the roots of plants can exercise their functions to the depth of five or six feet, while in others, they are confined to the vicinity of the surface, it must be obvious, "that without a knowledge of the respective depths and penetrability of two soils, a comparison of their plant-food percentages will be futile. Nor is it feasible to agree upon a certain depth to which all soils analyzed should be taken. The surface soil, with its processes of humification, nitrification, oxidation, carbonic acid solution, etc., in full progress, must always be distinguished from the subsoil in which these processes are but feebly developed, and where the store of plant-food—in which it is generally richer than the surface soil—is comparatively inert. Hence the obvious importance of specimens correctly taken, and the necessity of intelligent and accurate observations on the spot."

"*High*" *and* "*Low*" *Percentages and their Interpretation.*—The main points substantially proven by comparisons of soil analyses made upon the uniform plan outlined above, are thus summed up :

"1. *Other things being equal, the thriftiness, (i. e.*, present productiveness), *of a soil is measurably dependent upon the presence of a certain minimum percentage of lime.*"

This is proven by overwhelming evidence, and it is found "that in order to manifest itself unequivocally in the tree-growth, the lime-percentage should not fall below 0.100 in the lightest sandy soils ; in clay loams, not below a fourth of one per cent., 0.250 ; and in heavy clay soils, not below 0.5, and it may advantageously rise to one and even two per cent. Beyond the latter figure, it seems in no case to act more favorably than a less amount, unless it be mechanically."

"The effect produced by the presence of lime seems to be an energizing or rendering active of that which would otherwise remain inactive. . . . We have an instance of the same action in the case of marls, whose small percentages of potash and phosphates act so energetically, and in which we so often find the potash in the highly available form of glauconite grains ; also in the displacement of potash from zeolitic compounds, by lime or lime salts."

"From the evidence before me I should specify as follows the advantages resulting from the presence of an adequate supply of lime in soils :"

"*a.*—A more rapid transformation of vegetable matter into *active* humus, which manifests itself by a dark, or deep black tint of the soil."

"*b.*—The retention of such humus, against the oxidizing influences of hot climates ; witness the high humus percentages of such soils as against all others, in the Southern States."

"c.—Whether through the medium of this humus, or in a more direct manner it renders adequate for profitable culture percentages of phosphoric acid and potash so small that, in the case of deficiency or absence of lime, the soil is practically sterile."

"*d.*—It tends to secure the proper conditions for nitrification, whereby the inert nitrogen of the soil is rendered available."

"*e.*—It exerts a most important physical action on the flocculation, and therefore on the tillability of the soil as heretofore shown by Schlœsing and by myself."

"I may add that in the great majority of soils (excepting those that are extremely sandy), the lime-percentage is greater in the subsoil than in the surface soil. This is, doubtless, the result of the easy solubility of carbonate in the soil water, which carries it downward and thus tends to deplete the surface soil. . . . The efficacy of lime in preventing 'running to weed' in fresh soils, and in favoring the production of fruit, is conspicuously shown in a number of cases. This controlling influence of lime renders its determination, alone, a matter of no small interest, since its deficiency can very generally be cheaply remedied, avoiding the use of more costly fertilizers."

"I have been unable to trace any connection of *magnesia* with any of the important qualities of the soil. Its percentage is usually larger than that of lime, frequently about double."

"2. The *phosphoric acid* percentage is that which, in connection with the

lime, seems to govern most commonly the productiveness of our virgin soils. In any of these, less than five hundredths (0.05) must be regarded as a serious deficiency. In sandy loam soils, one-tenth (0.100), when accompanied by a fair supply of lime, secures fair productiveness for eight to fifteen years; with a deficiency of lime, twice that percentage will only serve for a similar time. The maximum percentage thus far found in an upland soil by my method of analysis, is about a quarter of one per cent. (0.250), in the splendid table land soils of West Tennessee and Mississippi. In the best bottom ("buckshot") soil of the Mississippi, three-tenths (0.300). In that of a black prairie of Texas, 0.46 per cent., this being the highest figure that has come under my observation."

"How the lime compounds contained in the soil act in rendering the phosphates more available, I do not pretend to discuss at present. A number (far too limited as yet) of determinations made according to Grandeau's method, appear to confirm the inference that calcareous soils yield to this treatment a larger relative percentage of available phosphoric acid, than those deficient in lime."

"3. The *potash percentages* of soils seem, in a large number of cases, to vary with that of "clay;" that is, in clay soils they are usually high, in sandy soils low; and since subsoils are in all ordinary cases more clayey than surface soils, their potash percentage is almost invariably higher also."

"1.3 (one and three-tenths) per cent. potash is the highest percentage obtained by my method of extraction, and that from the same soil that afforded the second highest phosphate percentage also, the "buckshot" of the Mississippi bottom, noted for its high and uniform production of cotton. As the same soil contains 1.4 per cent. of lime, and is jet black with humus, it may serve as the type of a fertile soil."

"The potash percentage of heavy clay upland soils and clay loams ranges from about 0.3 to 0.5 per cent., lighter loams from 0.45 to 0.30, sandy loams below 0.3, and sandy soils of great depth may fall below 0.100 consistently with good productiveness and durability; the former depending upon the amounts of lime and phosphoric acid with which it is associated. Virgin soils falling below 0.060 in their potash percentage seem, in all cases that have come under my observation, to be deficient in available potash, its application to such soils being followed by an immediate great increase of production."

"Since but few soils fall below this minimum, my general inference has been that potash manures are not among the first to be sought for after the soils have become "tired" by exhaustive culture. The universal preference given to phosphatic and nitrogenous fertilizers in the West and South, is in accord with this inference. In the older portions of the United States, 'kainite' is becoming more important, while in the alkali lands of California, soluble potash salts often impregnate the soil water."

"4. In all soils not specially impregnated with sea, or other salts, the amount of *soda* extracted by the acid is considerably *below* that of potash in the same soil, varying mostly from one-eighth to one-third of the percentage of the latter. When much more is found in such soils, a repetition of the determination will usually show that the separation from magnesia was imperfectly made. I can trace no connection between the soda percentage and any important property of the soil, any more than in the case

of *magnesia* and *manganese*, albeit none of these is ever absent from ordinary soils."

"5. *Sulphuric acid* is found in very small quantities only, even in highly fertile soils. From two to four hundredths of one per cent. (0.02 to 0.04) seems to be an adequate supply, but it frequently rises to one-tenth (0.1) per cent., rarely higher."

"6. *Chlorine* I have, as a rule, left undetermined, on account of its constant variability and universal presence in waters, and acknowledged slight importance to useful vegetation."

"7. *Iron*, in the shape of ferric hydrate finely diffused, appears to be an important soil ingredient on account of its physical, and partly, also, its chemical properties. The universal preference given to "red lands" by farmers, is sufficiently indicative of the results of experience in this respect, and I have taken pains to investigate its causes. The high absorptive power of ferric hydrate for gases is probably first among the benefits it confers. Red soils resist drouth better than similar soils lacking the ferric hydrate. . . The moisture co-efficient depends in ordinary soils, upon one or more of four substances, viz: (in the order of their efficacy) humus, ferric hydrate, clay, and lime.

It varies in cultivatable soils from about 1.5 to 23 per cent. at 15° c., and in a saturated atmosphere. A pure clay rarely exceeds 12 per cent; ferruginous clays show from 15 to 21; some calcareous clay soils rise nearly as high, while peaty soils rise to 23 per cent., and even more, but the efficacy of ferric hydrate depends essentially upon a state of fine division. When merely incrusting the sand grains, or aggregated into bog-ore grains, it exerts little or no influence, although analysis may show a high percentage. Sometimes soils highly colored show but small iron percentage, while yet, on account of very fine diffusion, the advantages referred to are realized."

"From 1.5 to 4.0 are ordinary percentages of ferric oxide, occurring even in soils but slightly tinted. Ordinary ferruginous loams vary from 3.5 to 7.0; highly colored 'red lands' have from 7 to 12 per cent., and occasionally upward to 20 and more."

"Of course, a large amount of ferric hydrate facilitates the tillage of heavy clay soils, and its color tends to the absorption of heat. But I incline strongly to the belief that the benefits of its presence are not confined to physical action. From the fact that highly ferruginous soils rarely have a high percentage of humus, it appears that the former acts as a carrier of oxygen to the latter, and thus probably favors, especially, nitrification."

"On the other hand, such soils are the first liable to damage from imperfect drainage, overflows, etc. The reduction of the ferric hydrate to ferrous salts, most commonly in the subsoil, manifests itself promptly by the 'blighting' of the crop. But under natural conditions this can rarely occur, because a frequent recurrence of conditions favoring reduction will inevitably result in a gradual bleaching of the soil, and an accumulation of its iron in the subsoil in the form of bog-ore or 'black pebble."

In addition to the analysis made as above indicated, tests were made upon a number of soils with the method of Grandeau, which consists in leaching from the soil all those constituents soluble in ammonia water, and then analyzing

the extract. It is believed by M. Grandeau that the "black matter" thus leached from the soil, represents its content of available plant food, and that such analysis may serve as an index of fertility. According to Dr. Hilgard, "there can be no reasonable doubt that what *is* extracted by Grandeau's ammonia water, is at the command of the solvents employed by plants; the only question is, to what extent plants can readily go beyond. This of course requires extended culture experiments, on a great variety of soils."

"The determination of the *phosphoric acid* and *silica* in the residues from the ignition of Grandeau's extracts have already furnished most important data concerning the cause of the productiveness of some soils having comparatively a low percentage of phosphates."

"As regards the determinations of *nitrogen* and its compounds in the virgin soils thus far analyzed, I have omitted them in part from want of time and proper appliances for these delicate determinations, and partly from a doubt of their usefulness. The constant variation and inter-convertibility of nitrates and ammonia compounds renders their determination at any given time, of interest for that time only; and as the nitrogen percentage of the mould of natural soils adapted to agriculture is not likely to vary much, the humus percentage may probably be taken as roughly proportional to the total nitrogen of the soil. A full investigation of this subject is, of course, also called for. On the other hand, I find that the fulfillment of the conditions of nitrification in the soil, is in all cases, a condition of its thriftiness."

With these extracts from the important paper of Dr. Hilgard, it is believed that the interpretation of the soil analyses which accompany this Report, will be possible, by every reader who carefully studies the conclusions above presented.

It will be seen that this plan takes into account, not only the chemical composition of the soil, but also its mechanical constitution, and its native growth, and there can be no doubt that an intelligent application of the principles above set forth, will enable us to determine the *natural deficiencies* of our soils and to suggest the means for their improvement.

4. *Inference from Actual Productions.*—The successful growth of plants is dependent upon certain chemical and physical qualities of the soil; in other words, plants analyze the soil most accurately, and if we always knew how rightly to interpret the results of this analysis, there would be no need of the other modes of soil investigation above noted.

a. UNDER NATURAL CONDITIONS.—Of all the methods used in judging the value of new lands, that which rests upon an examination of their natural growth, has perhaps the widest application. This growth, when rightly interpreted, gives us certain information, which may be all the more relied upon, when the original condition of the land has in no way been interferred with by cultivation. In common practice, attention is rarely paid to any but the forest trees, "yet," as remarked by Dr. Hilgard, "these are, for the most part, indicative rather of what, in the *agricultural sense*, is termed the subsoil, than that of the surface stratum usually turned by the plow—in the shallow tillage prevailing at present—which may be of totally different characters.

Although the herbaceous and other smaller plants give indication of the character of the *soil* as it is usually understood, yet a full appreciation of all the conditions necessary to their growth, requires an amount of special knowledge which places it beyond the reach of the majority to profit by the hints which they give.

Professor Hilgard, in his Geology of Mississippi, has given some very practical remarks as the result of his observations in this direction, and I can do no better than quote his words:

"As a general thing, the forest growth, when considered not only with regard to the *kind* (species), but also to the *form* and *size* of the trees, is a very safe guide in judging of the quality of land; and the systematic study of the subject, in connection with the analyses of soils, promises results of the highest practical importance. * * * But this criterion may not unfrequently lead to grave mistakes, unless a proper examination of the character of the soil and subsoil be made at the same time. Of cases of this kind, it may be well to give a few examples."

"The Black Jack Oak, when forming large, well-shaped trees, with regular and especially tall trunks, and closed tops, is justly considered a sign of no inferior soil. As a species, the Black Jack occupies some of the poorest, as well as the richest soils of the State. We see it in the prairies, * * in the rich, mellow table lands, * * on the best yellow loam uplands; while

on the other hand, the hopeless infertility of the sandy 'Black Jack ridges' of the hilly country is familiar."

"In each of these localities the tree has its characteristic features peculiar to the soil, and easily recognizable by the attentive observer. In the long-leaf pine region of the South, * * land has frequently been bought on the faith of some large Black Jack Oaks scattered among the Pine; yet the land, on cultivation, yielded no better results than adjoining tracts on which no Black Jack was to be seen. And, in truth, there was no perceptible difference between the character of the soils, such as the shallow tillage exhibited them."

"Yet, on examination, I found the tree to have given a correct indication; for at the depth of 8 to 12 inches (to which the plow had never penetrated), the white ashy soil is underlaid by a good yellow loam, which when turned up proves to be quite fertile. It was, of course, from this stratum that the tree had derived its nourishment; having little or nothing to do with the surface soil. Had the purchaser noted this fact, or paid more attention to the character of the smaller plants, the roots of which do not extend beyond the arable soil, he could not have been thus misled."

"Another case in point occurs on the Southern River counties, in the hilly, fertile loam lands bordering on the Mississippi river. Here the 'Poplar' or Tulip tree is quite common among the hills, and knowing the habits of this tree, we should at once conclude the soil of these hills to be very calcareous. Yet it is found that most of these very soils are much improved by the application of lime; analysis, moreover, does not allot to them any unusual per centage of that substance. A little attention, however, will show the tree to be consistent in its indication, nevertheless."

"The main mass of these hills * * consists of the highly calcareous silt or loam of the Bluff formation; in most cases, however, the latter is overlaid, and the soil is formed by a brown loam of a different character and more modern age."

"It generally caps the hills, and also forms their talus, while on the brow of the hills, where the *level breaks off*, the calcareous loam of the bluff formation is generally *near to*, and sometimes *at* the surface; the same is the case, of course, in washes and gullies on the hillsides. Now, these are precisely the spots on which the 'Poplar' is most frequently seen, viz: on the hill-*sides*, rather than on the level area on top, which is chiefly cultivated. And when the 'Poplar' *is* found on the hill-tops, as is frequently the case where the ridges are high and narrow, examination will generally show that the brown loam stratum is nearly or entirely wanting, while the roots of the trees bury themselves in the calcareous silt. The latter then forms the arable soil, to which an application of lime would be perfectly useless."

"These examples may suffice to show that while in the forest trees we possess trustworthy guides to a knowledge of the character of the material in which their roots are buried, it is quite essential to convince ourselves at the same time, by inspection, that it is the arable soil itself, and not merely the subsoil which is thus characterized; and we should especially make sure that the smaller plants, viz: the *shrubs* and *perennials*, corroborate the evidence of the trees. Annuals are less reliable in their indications, because their development is to a greater extent influenced by the accidental circumstances of the seasons."

b. UNDER ARTIFICIAL CONDITIONS; FIELD EXPERIMENTS. The value of a soil in an agricultural sense, depends upon its capability of producing profitable crops of certain plants, the number of which is comparatively quite limited. To gain a knowledge of the soil's capabilities with respect to these few plants, by means of direct tests applied to the fields, would appear to be a comparatively simple matter, but in order that our deductions may not be erroneous, account must be taken of all the circumstances which can in any way modify the result; this, of course, requires a certain amount of special knowledge, and a great degree of care.

Each field experiment should be so arranged as to ask a direct question of the soil, and should be so conducted that an unequivocal answer must of necessity be returned.

For these trial crops a piece of land is selected as level as possible, and as nearly as possible of uniform quality of soil and subsoil. The separate plats or rows are then prepared by applying suitable manures, or by leaving unmanured; the seed sown, and the resulting products observed.

The *first question*, to be determined is: Is the soil deficient in nitrogen, or in phosphoric acid, or in potash; or in two of these, or in all three?

The most commonly occurring case will be to decide whether the land needs nitrogen or phosphoric acid, or both.*

To answer these questions, the plats are manured—

(a.) With *nitrogenous manures;* sulphate of ammonia (observing that this salt, besides being a nitrogenous compound, contains also sulphuric acid, itself a nutritive substance, to which a part of the action observed may be owing), or Chilian saltpetre (remembering that this substance acts not only as a nutritive manure, by enriching the soil with assimilable nitrogenous compounds, but is also stimulating as a salt of soda; and that it may be a question whether the results obtained are to be ascribed to the nutritive action of the nitrogen, or to the stimulating action of the saltpetre).

(b.) With *phosphatic manures;* as the common pure super-phosphates (noting that all super-phosphates contain gypsum (sulphate of lime), which may produce some part of the effects observed). To get a clear judgment, therefore, gypsum must also be used alone on another plat.

(c.) With a *mixture of both nitrogenous and phosphatic manures,* in the same quantities that each was employed by itself.

The results of the experiments may be as follows:

In case the soil lacked nitrogen alone, then the experiments *a* and *c* must give the same yield; if phosphoric acid alone were deficient, then *b* and *c*

* In the description of these experiments, I shall follow Heinrich (Grundlagen zur Beurtheilung der Ackererde).

would show the same yield. If the soil lacked both phosphoric acid and nitrogen, then *c* alone would give the greatest yield. If the components of gypsum (sulphuric acid and lime) were the only active principles in the manure used, this would be shown both in the direct experiment with gypsum, and also in *b* and *c*.

If the experiments are to show whether or not potash may also be deficient, another arrangement would be necessary, using as a special *potash manure*, the concentrated Stassfurth potash salts. The plats or rows could then be treated as follows:

(a.) Potash manure alone.
(b.) Gypsum (as a constituent of the super-phosphate).
(c.) Phosphoric acid (super-phosphate).
(d.) Nitrogenous manure (desiccated blood, or Chilian saltpetre).
(e.) Potash and Phosphoric acid combined.
(f.) Potash and nitrogen combined.
(g.) Phosphoric acid and nitrogen combined.
(h.) Phosphoric acid, nitrogen and potash combined.

If a suitable field has been selected, then the experiments above must of necessity answer the question whether the soil is deficient in potash, or in the constituents of gypsum, or in phosphoric acid, or in nitrogen alone, or in two or more of these at the same time.

The manures should be used in equal quantities whether applied alone or mixed with each other, since correct inferences from the results are thus made easier.

Now, if potash alone be the lacking element, then the tracts *a*, *e*, *f*, and *h* should all give approximately equal yields; if the yield of *e* (and also of *h*), were higher than that of *a*, it would show that the soil lacked phosphoric acid as well as potash.

Having in this way ascertained the needs of the soil with respect to available plant-food, the *next question* would be, In what form may the lacking substance be most profitably added, (*i. e.*, so as to cause the greatest yield, and with the least cost)?

To answer this, comparative trials may be made with the following substances, taking into consideration their relative cost.

a. Potash; the crude or concentrated potash salts of various kinds, of the Stassfurth mines.

b. Phosphoric acid; the several varieties of super-phosphates (taking into consideration their content of soluble phosphoric acid), precipitated phosphate of lime, super-phosphates of various kinds, together with the so-called reverted phosphoric acid.

c. Nitrogen; desiccated blood, saltpetre, sulphate of ammonia, and the several nitrogenous manures enumerated in the preceding pages.

d. Phosphoric acid and *nitrogen;* mixtures of the substances under *b* and *c*, "sulphated" or "dissolved" Peruvian guanos, fish guano, bone meal.

In all such experiments the percentage of the manuring principle must be accurately known, and in order that the action of the several manures may be more clearly seen, alternate plats should be left unmanured.

PART II.

AN ACCOUNT OF THE MAIN AGRICULTURAL FEATURES OF THE STATE OF ALABAMA.

TABULATED RESULTS OF THE ENUMERATION.

CENSUS OF 1880.

TABLE I.—AREA, POPULATION, TILLED LAND, AND COTTON PRODUCTION.

TABLE II.—ACREAGE AND PRODUCTION OF LEADING CROPS.

TABULATED RESULTS OF THE ENUMERATION.

TABLE I.—AREA, POPULATION, TILLED LAND, AND COTTON PRODUCTION.

COUNTIES.	Areas (square miles).	POPULATION.						TILLED LANDS.		COTTON PRODUCTION.								
		Total.	Male.	Female	White.	Color'd	Per square mile.	Acres.	Percentage of area.	Percentage of tilled lands in cotton.	Acres.	Bales.	Average per acre.			Cotton acreage per square mile.	Bales per square mile.	
													Bale.	Seed-cotton.	Lint.			
The State	51,540	1,262,505	622,629	639,876	662,185	600,320	24	6,134,198	19	38	2,330,086	699,654	0.30	429	143	45	14	
METAMORPHIC REGION.																		
Cleburne	540	10,976	5,356	5,620	10,308	668	20	51,428	15	18	9,156	3,600	0.39	555	185	17	7	
Randolph	610	16,575	8,198	8,377	13,155	3,420	27	81,426	21	28	23,177	7,475	0.32	456	152	38	12	
Chambers	610	23,440	11,517	11,923	11,364	12,076	38	149,283	38	48	70,934	19,476	0.27	384	128	116	32	
Lee	610	27,262	13,079	14,183	12,217	15,045	45	122,875	31	42	51,889	13,189	0.25	357	119	85	22	
Tallapoosa	810	23,401	11,578	11,823	16,108	7,293	29	143,175	28	29	41,200	14,161	0.34	486	162	51	12	
Clay	610	12,938	6,330	6,608	11,870	1,068	21	57,972	15	24	13,921	4,973	0.36	513	171	23	8	
Coosa	670	15,113	7,500	7,613	10,050	5,063	23	80,791	19	33	26,468	8,411	0.32	456	152	40	13	
Total	4,400	129,705	63,558	66,147	85,072	44,633	29	686,950	24	34	236,745	71,285	0.30	429	143	53	16	

TABULATED RESULTS OF THE ENUMERATION.

TABLE I.—AREA, POPULATION, TILLED LAND, AND COTTON PRODUCTION—Continued.

COUNTIES.	Areas (square miles).	POPULATION.						TILLED LANDS.		COTTON PRODUCTION.							
		Total.	Male.	Female	White.	Color'd	Per square mile.	Acres.	Percentage of area.	Percentage of tilled lands in cotton.	Acres.	Bales.	Average per acre.			Cotton acreage per square mile.	Bales per square mile.
													Bale.	Seed-cotton.	Lint.		
COOSA VALLEY REGION.																	
Cherokee	660	19,108	9,679	9,429	16,418	2,690	29	88,819	21	27	24,388	10,777	0.44	627	209	37	16
Calhoun	640	19,591	9,836	9,755	14,134	5,457	31	93,857	23	28	26,435	10,848	0.41	585	195	41	17
Etowah	520	15,398	7,703	7,695	12,896	2,502	30	60,780	18	25	15,187	6,571	0.43	612	204	29	13
Saint Clair	630	14,462	7,231	7,231	11,621	2,841	23	65,105	16	23	14,735	6,028	0.41	585	195	23	10
Talladega	700	23,360	11,380	11,980	10,856	12,504	33	113,389	25	29	32,841	11,832	0.36	513	171	47	17
Shelby	780	17,236	8,664	8,572	12,253	4,983	22	58,550	12	31	17,919	6,643	0.37	528	176	23	9
Total	3,930	109,155	54,493	54,662	78,178	30,977	28	480,500	19	27	131,505	52,699	0.40	570	190	33	13
COAL-MEASURES REGION.																	
DeKalb	740	12,675	6,300	6,375	11,993	682	17	52,096	11	14	7,469	2,859	0.38	543	181	10	4
Marshall	560	14,585	7,208	7,377	13,084	1,501	26	68;175	19	24	16,412	5,358	0.33	471	157	29	10
Cullman	590	6,355	3,234	3,121	6,312	43	11	20,527	5	7	1,469	378	0.26	372	124	2	1
Blount	700	15,369	7,644	7,725	14,210	1,159	22	68,860	15	18	12,502	4,442	0.36	513	171	18	6
Jefferson	960	23,272	11,896	11,376	18,219	5,053	24	71,959	12	20	14,220	5,333	0.38	543	181	15	6
Walker	880	9,479	4,633	4,846	8,978	501	11	46,725	8	19	8,743	2,754	0.32	441	147	10	3
Winston	640	4,253	2,131	2,122	4,236	17	7	17,767	4	12	2,048	568	0.28	399	133	3	1
Total	5,070	85,988	43,046	42,942	77,032	8,956	17	346,109	11	18	62,863	21,692	0.35	498	166	12	4

TENNESSEE VALLEY REGION.																	
Jackson	990	25,114	12,626	12,488	21,074	4,040	25	123,924	20	16	19,685	6,235	0.32	456	152	20	6
Morgan	700	16,428	8,185	8,243	11,758	4,670	23	95,584	21	20	18,828	6,133	0.33	471	157	27	9
Madison	810	37,625	18,538	19,087	18,591	19,034	46	213,221	41	34	72,838	20,679	0.28	399	133	90	26
Limestone	590	21,600	10,762	10,838	11,637	9,963	37	129,477	34	34	44,234	15,724	0.35	498	163	75	27
Lauderdale	700	21,035	10,485	10,550	14,173	6,862	30	102,839	23	26	26,594	9,270	0.35	498	166	38	13
Lawrence	790	21,392	10,620	10,772	12,642	8,750	27	138,034	27	31	42,803	13,791	0.32	456	152	54	17
Colbert	570	16,153	7,980	8,173	9,203	6,950	28	74,876	21	34	25,411	9,012	0.36	498	166	45	16
Franklin	610	9,155	4,523	4,632	8,079	1,076	15	46,895	12	22	10,368	3,603	0.35	498	166	17	6
Total	5,760	168,502	83,719	84,783	107,157	61,345	29	924,850	25	28	260,861	84,447	0.32	456	152	45	15
OAK AND HICKORY UPLANDS WITH SHORT-LEAF PINE.																	
Marion	810	9,364	4,599	4,765	8,841	523	12	42,925	8	17	7,269	2,240	0.31	441	147	9	3
Lamar	590	12,142	5,992	6,150	9,967	2,175	21	62,141	16	25	15,245	5,015	0.33	471	157	26	8
Fayette	660	10,135	5,061	5,074	8,873	1,262	15	56,118	13	22	12,331	4,268	0.35	498	166	19	6
Pickens	1,000	21,479	10,605	10,874	9,132	12,347	21	115,560	18	46	52,651	17,283	0.33	471	157	53	17
Total	3,060	53,120	26,257	26,863	36,813	16,307	17	276,744	14	32	87,496	28,806	0.33	471	157	29	9
GRAVELLY HILLS, WITH LONG-LEAF PINE.																	
Tuscaloosa	1,390	24,957	12,104	12,853	15,216	9,741	18	111,171	12	30	33,773	11,137	0.33	471	157	24	8
Bibb	610	9,487	4,664	4,823	5,887	3,600	16	43,796	11	36	15,737	4,843	0.31	441	147	26	8
Chilton	700	10,793	5,418	5,375	8,651	2,142	15	40,676	9	28	11,558	3,534	0.31	441	147	16	5
Autauga	660	13,108	6,451	6,657	4,397	8,711	20	81,388	19	37	30,474	7,944	0.26	372	124	46	12
Elmore	630	17,502	8,780	8,722	8,747	8,755	28	73,897	18	42	31,045	9,771	0.31	441	147	49	16
Ttoal	3,990	75,847	37,417	38,430	42,898	32,949	19	350,928	14	35	122,587	37,229	0.30	429	143	31	9

TABULATED RESULTS OF THE ENUMERATION.

TABLE I.—AREA, POPULATION, TILLED LAND, AND COTTON PRODUCTION—Continued.

COUNTIES.	Areas (square miles).	POPULATION.						TILLED LANDS.		COTTON PRODUCTION.							
		Total.	Male.	Female	White.	Color'd	Per square mile.	Acres.	Percentage of area.	Percentage of tilled lands in cotton.	Acres.	Bales.	Average per acre.			Cotton acreage per square mile.	Bales per square mile.
													Bale.	Seed-cotton.	Lint.		
OAK AND HICKORY UPLANDS, WITH LONG-LEAF PINE.																	
Choctaw	930	15,731	7,750	7,981	7,390	8,341	17	77,182	13	40	31,086	9,054	0.29	414	138	33	10
Clarke	1,160	17,806	8,797	9,009	7,718	10,088	15	77,186	10	43	33,477	11,097	0.33	471	157	29	10
Monroe	1,030	17,091	8,344	8,747	7,780	9,311	17	77,317	12	43	33,463	10,421	0.31	441	147	32	10
Wilcox	960	31,828	15,624	16,204	6,711	25,117	33	161,228	26	48	77,076	26,745	0.35	498	166	80	28
Butler	800	19,649	9,483	10,166	10,684	8,965	25	87,010	17	41	35,851	11,895	0.33	471	157	45	15
Conecuh	840	12,605	6,257	6,348	6,224	6,381	15	46,965	9	35	16,523	4,633	0.28	399	133	20	6
Crenshaw	660	11,726	5,741	5,985	9,118	2,608	18	67,770	16	40	26,962	8,173	0.30	429	143	41	12
Pike	740	20,640	10,157	10,483	14,368	6,272	28	114,850	24	41	47,107	15,136	0.32	456	152	64	20
Coffee	700	8,119	4,025	4,094	6,831	1,288	12	42,126	9	39	16,431	4,788	0.29	414	138	23	7
Dale	650	12,677	6,174	6,503	10,553	2,124	20	68,413	16	40	27,076	6,224	0.23	327	109	42	10
Henry	1,000	18,761	9,251	9,510	11,994	6,767	19	137,348	21	40	54,305	12,573	0.23	327	109	54	13
Total	9,470	186,633	91,603	95,030	99,371	87,262	20	957,395	16	42	399,357	120,739	0.30	429	143	42	13

CENTRAL PRAIRIE REGION.																	
Sumter	1,000	28,728	13,982	14,746	6,451	22,277	29	172,100	27	47	80,662	22,211	0.28	399	133	81	22
Greene	520	21,931	10,823	11,108	3,765	18,166	42	119,426	36	53	63,643	15,811	0.25	357	119	122	30
Hale	670	26,553	13,196	13,357	4,903	21,650	40	140,072	33	50	69,995	18,093	0.26	372	124	104	27
Marengo	960	30,890	15,139	15,751	7,277	23,613	32	169,097	28	48	80,790	23,481	0.29	414	138	84	24
Perry	790	30,741	15,050	15,691	7,150	23,591	39	167,666	33	44	74,303	21,627	0.29	414	138	94	27
Dallas	980	48.433	23,824	24,609	8,425	40,008	49	207,404	33	56	115,631	33,534	0.28	414	138	118	34
Lowndes	740	31,176	15,552	15,624	5,645	25,531	42	181,272	38	54	98,200	29,356	0.30	429	143	133	40
Montgomery	740	52,356	25,563	26,793	13,457	38,899	71	241,570	51	46	112,125	31,732	0.28	399	133	152	43
Bullock	660	29,066	14,345	14,721	6,944	22,122	44	176,860	42	45	80,470	22,578	0.28	399	133	122	34
Macon	630	17,371	8,434	8,937	4,587	12,784	28	133,924	33	42	56,763	14,580	0.26	372	124	90	23
Russell	670	24,837	12,109	12,728	6,182	18,655	37	134,320	31	61	81,582	19,442	0.24	342	114	122	29
Barbour	860	33,979	16,774	17,205	13,091	20,888	40	197,455	36	51	100,442	26,063	0.26	372	124	117	30
Total	9,220	376,061	184,791	191,270	87,877	288,184	41	2,041,166	35	50	1,014,606	278,508	0.27	384	128	110	20
LONG-LEAF PINE REGION.																	
Washington	1,050	4,538	2,341	2,197	2,807	1,731	4	8,936	1	37	3,280	1,246	0.38	543	181	3	1
Mobile	1,290	48,653	23,086	25,567	27,187	21,466	38	8,998	1	....	1	1	....	....	....	....	....
Baldwin	1,620	8,603	4,430	4,173	4,890	3,713	5	7,698	1	18	1,384	.638	0.46	657	218	1	..
Escambia	1,000	5,719	2,933	2,786	4,106	1,613	6	9,934	1	4	278	94	0.34	486	162	....	..
Covington	1,030	5,639	2,757	2,882	4,968	671	5	19,326	3	22	4,176	1,158	0.28	399	133	4	1
Geneva	590	4,342	2,198	2,144	3,829	513	7	17,664	5	28	4,947	1,112	0.23	327	109	8	2
Total	6,580	77,494	37,745	39,749	47,787	29,707	12	69,556	2	20	14,066	4,249	0.30	429	143	2	1

TABULATED RESULTS OF THE ENUMERATION.

TABLE I.—AREA, POPULATION, TILLED LAND, AND COTTON PRODUCTION.

COUNTIES.	Areas (square miles).	POPULATION.						TILLED LANDS.		COTTON PRODUCTION.								
		Total.	Male.	Female	White.	Color'd	Per square mile.	Acres.	Percentage of area.	Percentage of tilled lands in cotton.	Acres.	Bales.	Average per acre.			Cotton acreage per square mile.	Bales per square mile.	
													Bale.	Seed-cotton.	Lint.			
The State	51,540	1,262,505	622,629	639,876	662,185	600,320	24	6,134,198	19	38	2,330,086	699,654	0.30	429	143	45	14	
METAMORPHIC REGION.																		
Cleburne	540	10,976	5,356	5,620	10,308	668	20	51,428	15	18	9,156	3,600	0.39	555	185	17	7	
Randolph	610	16,575	8,198	8,377	13,155	3,420	27	81,426	21	28	23,177	7,475	0.32	456	152	38	12	
Chambers	610	23,440	11,517	11,923	11,364	12,076	38	149,283	38	48	70,934	19,476	0.27	384	128	116	32	
Lee	610	27,262	13,079	14,183	12,217	15,045	45	122,875	31	42	51,889	13,189	0.25	357	119	85	22	
Tallapoosa	810	23,401	11,578	11,823	16,108	7,293	29	143,175	28	29	41,200	14,161	0.34	486	162	51	12	
Clay	610	12,938	6,330	6,608	11,870	1,068	21	57,972	15	24	13,921	4,973	0.36	513	171	23	8	
Coosa	670	15,113	7,500	7,613	10,050	5,063	23	80,791	19	33	26,468	8,411	0.32	456	152	40	13	
Total	4,400	129,705	63,558	66,147	85,072	44,633	29	686,950	24	34	236,745	71,285	0.30	429	143	53	16	

TABULATED RESULTS OF THE ENUMERATION.

TABLE I.—AREA, POPULATION, TILLED LAND, AND COTTON PRODUCTION—Continued.

COUNTIES.	Areas (square miles).	POPULATION.						TILLED LANDS.		COTTON PRODUCTION.							
		Total.	Male.	Female	White.	Color'd	Per square mile.	Acres.	Percentage of area.	Percentage of tilled lands in cotton.	Acres.	Bales.	Average per acre.			Cotton acreage per square mile.	Bales per square mile.
													Bale.	Seed-cotton.	Lint.		
OAK AND HICKORY UPLANDS, WITH LONG-LEAF PINE.																	
Choctaw	930	15,731	7,750	7,981	7,390	8,341	17	77,182	13	40	31,086	9,054	0.29	414	138	33	10
Clarke	1,160	17,806	8,797	9,009	7,718	10,088	15	77,186	10	43	33,477	11,097	0.33	471	157	29	10
Monroe	1,030	17,091	8,344	8,747	7,780	9,311	17	77,317	12	43	33,463	10,421	0.31	441	147	32	10
Wilcox	960	31,828	15,624	16,204	6,711	25,117	33	161,228	26	48	77,076	26,745	0.35	498	166	80	28
Butler	800	19,649	9,483	10,166	10,684	8,965	25	87,010	17	41	35,851	11,895	0.33	471	157	45	15
Conecuh	840	12,605	6,257	6,348	6,224	6,381	15	46,965	9	35	16,523	4,633	0.28	399	133	20	6
Crenshaw	660	11,726	5,741	5,985	9,118	2,608	18	67,770	16	40	26,962	8,173	0.30	429	143	41	12
Pike	740	20,640	10,157	10,483	14,368	6,272	28	114,850	24	41	47,107	15,136	0.32	456	152	64	20
Coffee	700	8,119	4,025	4,094	6,831	1,288	12	42,126	9	39	16,431	4,788	0.29	414	138	23	7
Dale	650	12,677	6,174	6,503	10,553	2,124	20	68,413	16	40	27,076	6,224	0.23	327	109	42	10
Henry	1,000	18,761	9,251	9,510	11,994	6,767	19	137,348	21	40	54,305	12,573	0.23	327	109	54	13
Total	9,470	186,633	91,603	95,030	99,371	87,262	20	957,395	16	42	399,357	120,739	0.30	429	143	42	13

CENTRAL PRAIRIE REGION.												
Sumter	80,662	22,211	51,403	699,883	2,706	31,380	24	225	13	2,627	1,056	96,402
Greene	63,643	15,811	31,826	402,992	2,163	22,464	314	1,803	41	6,829	705	64,074
Hale	69,995	18,093	43,254	595,185	3,671	45,075	1,437	15,273	16	5,540	1,214	77,830
Marengo	80,790	23,481	43,876	698,009	6,574	83,234	.....	.....	43	7,479	1,138	95,625
Perry	74,303	21,627	48,132	628,248	6,093	63,710	440	2,974	24	4,522	1,107	77,660
Dallas	115,631	33,534	46,542	707,139	8,260	111,213	71	487	13	1,678	2,256	137,387
Lowndes	98,200	29,356	41,169	611,184	3,630	43,922	.....	.....	.....	.....	1,004	68,587
Montgomery	112,125	31,732	62,303	767,427	4,895	62,292	58	393	2	318	1,720	117,285
Bullock	80,470	22,578	47,441	379,876	6,177	43,028	111	455	3	833	773	67,008
Macon	56,763	14,580	23,833	173,969	6,195	53,336	1,916	9,094	6	680	928	60,374
Russell	81,582	19,442	34,335	215,555	9,789	91,141	1,099	6,771	2	303	1,093	80,264
Barbour	100,442	26,063	61,822	437,415	10,264	99,295	131	530	22	3,512	1,274	112,374
Total	1,014,606	278,508	535,935	6,316,882	70,414	750,090	5,601	38,005	185	34,321	14,268	1,054,870
LONG-LEAF PINE REGION.												
Washington	3,280	1,246	4,259	58,105	464	3,547	.....	.....	.....	.....	448	40,695
Mobile	1	1	1,639	25,272	139	1,440	.....	.....	.....	.....	776	58,695
Baldwin	1,384	638	2,041	28,428	350	5,108	.....	.....	1	350	484	50,025
Escambia	278	94	3,699	34,336	869	8,979	.....	.....	.....	.....	494	42,013
Covington	4,176	1,158	10,558	81,997	2,114	16,266	.....	.....	8	1,764	466	43,890
Geneva	4,947	1,112	9,476	58,887	1,705	10,604	.....	.....	4	948	350	33,492
Total	14,066	4,249	31,672	287,025	5,641	45,944	.....	.....	13	3,062	3,018	268,810

TABULATED RESULTS OF THE ENUMERATION.

TABLE II.—ACREAGE AND PRODUCTION OF LEADING CROPS.

COUNTIES.	COTTON.		INDIAN CORN.		OATS.		WHEAT.		TOBACCO.		SWEET POTATOES.	
	Acres.	Bales.	Acres.	Bushels.	Acres.	Bushels.	Acres.	Bushels.	Acres.	Pounds	Acres.	Bushels.
Total for the State	2,330,086	699,654	2,055,929	25,451,278	324,628	3,039,639	264,971	1,529,657	2,197	452,426	43,256	3,448,819
METAMORPHIC REGION.												
Cleburne	9,156	3,600	21,552	362,335	5,672	58,084	7,504	48,904	85	15,113	221	25,246
Randolph	23,177	7,475	29,595	332,466	4,850	43,558	10,155	58,379	44	11,521	433	36,873
Chambers	70,934	19,476	49,306	458,286	9,258	80,592	11,520	75,945	39	8,055	1,038	83,116
Lee	51,889	13,189	30,137	244,903	11,918	101,911	8,697	50,225	11	1,766	925	70,011
Tallapoosa	41,200	14,161	41,415	461,960	9,106	78,684	14,572	99,061	21	5,350	408	40,308
Clay	13,921	4,973	24,503	292,870	4,834	39,308	9,785	54,603	85	13,468	237	28,120
Coosa	26,468	8,411	29,990	364,399	5,325	41,758	9,735	55,028	28	5,258	412	33,268
Total	236,745	71,285	226,498	2,517,219	50,963	443,895	71,968	442,145	313	60,531	3,674	316,942
COOSA VALLEY REGION.												
Cherokee	24,388	10,777	33,373	509,381	7,477	66,215	10,085	66,956	82	14,318	335	20,765
Calhoun	26,435	10,848	33,714	469,598	8,852	93,368	10,745	67,660	29	6,592	283	27,876
Etowah	15,187	6,571	24,891	382,788	5,025	44,734	7,063	40,192	47	11,333	230	19,631
Saint Clair	14,735	6,028	25,465	341,703	4,603	41,291	9,841	54,853	53	11,208	226	22,187
Talladega	32,841	11,832	40,376	454,873	9,278	92,356	13,233	89,868	30	5,520	335	22,872
Shelby	17,919	6,643	26,159	312,839	4,764	39,348	6,294	34,324	10	2,298	346	30,654
Total	131,505	52,699	183,978	2,471,182	39,999	377,312	57,261	353,853	251	51,269	1,755	143,985

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SECTION I.

AN OUTLINE OF THE PHYSICAL GEOGRAPHY AND GEOLOGY OF ALABAMA, AND AN ENUMERATION OF THE AGRICULTURAL SUBDIVISIONS OR REGIONS OF THE STATE.

Alabama is situated between the eighty-fifth and eighty-ninth degrees of west longitude and the thirty-first and thirty-fifth parallels of north latitude. The thirty-fifth parallel makes the northern boundary of the State, and the thirty-first the southern, with the exception of that portion west of the Perdido river, which extends south to the Gulf of Mexico. The form is thus seen to be oblong, with the greater dimension from north to south. The total area thus included is, according to the latest estimates, 52,250 square miles, and the total land surface, 51,540 square miles.

SURFACE CONTOUR.—Leaving out of account the minor irregularities, the surface of the State may be considered as an undulating plain, whose mean elevation above sea-level cannot be much less than 600 feet. Toward the north and east the surface rises above this level, and toward the south and west it sinks below it. The arc of a circle, with Chattanooga as a center, described from the northwestern corner of the State around to the Chattahoochee river at Columbus, would include the area whose general elevation is above 600 feet. The axis of this elevation, which is the southern terminus of the great Appalachian mountain chain, runs northeast and southwest, and the altitude increases toward the northeast. There is thus a general slope away from this elevated region toward all points of the compass from southeast around to northwest. The mountains of the State rest upon this high land, and often reach an elevation above

it of 1,200 or 1,500 feet, or above sea-level of 2,000 or 2,500 feet.

The rest of the State, outside of the area above mentioned, and whose general altitude is less than 600 feet, has a slope south and southwest toward the Gulf of Mexico and the Mississippi Valley. Along this slope the streams have excavated their channels and produced the various topographical features, none of which are due to elevation above the general surface.

River Systems.—There are, in the most general terms, two things which have determined the drainage system of Alabama. These, are, first, the slopes toward the northwest and the southeast, away from the axis of elevation above spoken of; and, second, the more general slope of the surface of the State, taken as a whole, southwest toward the axis of the Mississippi Valley. An inspection of the map will show that the latter cause has greatly outweighed the former in fixing the direction of the watercourses, with the result of giving a general southwest direction to the whole drainage system of the State, with the single exception of that of the Tennessee river. In the northeastern part of the State the northeast and southwest direction of the valleys and ridges has also been largely instrumental in turning southwestward (down the valleys) the waters whose natural fall is southeastward at right angles to the axis of elevation of this mountainous region.

Tennessee River.—Looking beyond the limits of the State northeastwardly, we find the Blue Ridge, of which the elevated country in Alabama is but a part, acting as a watershed between the Atlantic ocean and the Gulf of Mexico. The drainage slopes are, therefore, toward the northwest and the southeast. At the northwestern foot of this watershed, in North Carolina, are the headwaters of the Tennessee river. Its natural northwesterly flow is interfered with by the topographical features of the country, the most formidable of which, according to Professor Safford, is the great Cumberland table-land. Parallel with this the river flows through a large part of Tennessee, and, cutting through a detached part of the Cumberland range at Chattanooga, it enters the Sequatchie Valley, which it follows to

Guntersville, in Alabama, where it cuts through the rest of the Cumberland range, and flows thence down the northwesterly slope to its confluence with the Mississippi river. The Tennessee is thus exceptional among the rivers of Alabama.

The Chattahoochee.—This is a boundary stream, and is but slightly related to Alabama, as its headwaters are principally in Georgia. Its tributary streams on the Alabama side are mostly short and insignificant.

The Tallapoosa, Coosa, Alabama, Warrior, and Lower Tombigbee rivers have many things in common. They all have their headwaters in the elevated region above alluded to, and all flow south and southwest into the Gulf of Mexico. In their upper parts, with the exception of the Tombigbee, their flow is alternately southwest down to one of the valleys spoken of, and then south across a ridge to resume their southwestern courses. Where they leave that elevated region (which is in general formed of the tough and hard rocks of the older formations) and pass into the territory formed by the newer and softer rocks there appear the cascades which form the first obstructions to navigation. These falls, or rapids, are seen at Columbus (Georgia), Tallassee, Wetumpka, Centerville, Tuscaloosa, and Muscle Shoals, on the principal rivers, and at corresponding localities on the smaller streams.

The Coosa river, from Rome, Georgia, down to Greensport, Alabama, flows in general along the strike of the rocks and has no serious obstructions. Below Greensport it turns across these rocks, and rapids are formed, which alternate with stretches of open, smooth waters down to Wetumpka, where the last falls are situated. This river has thus two navigable sections separated by nearly 200 miles of alternating cascades and pools. None of the other rivers of this group are navigable above the lower falls.

The Choctawhatchie and Conecuh rivers, with their tributaries, Pea river, Patsaliga, Sepulga, etc., are all turned southward by a prominent topographical feature known as Chunnenugga Ridge, which divides the waters flowing northwestward into the Tallapoosa and Alabama rivers from those flowing southward by various channels into the Gulf. It

will be seen that their general direction is west of south, as determined by the general slope of the lower portion of the State.

MOUNTAINS AND TABLE-LANDS.—The mountainous region of the State is confined to the northeastern quarter, as before defined, and the higher portions lie in the eastern half of this area. The Valley of the Coosa, from the State line down to the southern line of Shelby and Talladega counties, divides this region into parts which have very different characters. Southeast of this valley are some of the highest lands of the State, and the height of the mountains decreases, as a rule, going southeast. In all this region the summits of the mountains are irregular, and sometimes sharp crested, from the outcropping edges of the generally highly-inclined strata. Northwest of the Coosa Valley the mountains are generally level on top, forming table-lands 10 to 15 miles broad, separated by long and narrow valleys. Beyond the Tennessee river these table-lands are cut by erosion into a number of detached peaks, each with a level or nearly level top. These peaks overlook the valleys in steep escarpments, which, especially in the northeast, often attain truly mountainous proportions.

In the lower part of the State there are no elevations which at all deserve the name of mountains, and the highest hills of this region are due solely to erosion—the wasting of the softer rocks by the action of water.

VALLEYS.—Many of the valleys of the elevated region show a close dependence upon the geological structure, and while they are all due to erosion, their position has been in most, if not all, cases determined by the relative positions of the outcropping edges of the strata of different degrees of hardness.

All the valleys in the mountainous region of the State, like the mountain ranges themselves, have a northeast and southwest direction. The most important of these valleys in many respects is that of the Coosa, which is the southern end of a series of valleys extending from New York to Alabama, and known in New York as the valley of the Hudson, in Pennsylvania as the Kittatinny or Cumberland valley, in

Virginia as the Great valley, in Tennessee as the valley of East Tennessee, and in Alabama, as we have just seen, as the Coosa Valley. The several outliers of this valley, which separate the parts of the table-lands and coal-fields, belong to the same general system.

The sandstones which form the capping of the mountain plateaus of North Alabama, rest upon softer strata of shales and limestones, and the dip of all the strata is at a gentle angle toward the south or southwest, while the Tennessee river cuts across at nearly right angles. These are the conditions under which escarpments are formed, such as make the southern border of the Tennessee Valley across the State.

In the lower part of the State the valleys, like the hills, have very little relation to the geological structure, except in the case of the prairie region, which may be considered as a wide valley, since it is many feet below the hills that border it on the north and south.

CLIMATE.—The most potent influences which determine climate are latitude or distance from the equator, elevation above tide, and configuration of mountain chains, proximity to the sea, and the direction of the prevailing winds. In all these particulars the position of Alabama is favorable for a temperate and uniform climate. The geographical position and the mean elevation of the State have already been subjects of discussion.

Winds.—The prevailing winds during the autumn and winter months are from the northeast and northwest; during the spring and summer, from the southeast; and for the whole year, from the southeast and south, but the yearly mean directions are nearly evenly balanced.

Temperature.—Extremes of temperature are comparatively rare, and the extremes of heat during the summer months are especially moderated by the tempering winds from the Gulf of Mexico. In those parts of the State most remote from the Gulf their elevation above sea-level secures immunity from excessive heat. The mean annual temperature of the State is about 64.58° F. The means for the seasons are as follows: Spring, 63.9°; summer, 79.5°; autumn, 64.5°; winter, 50.4°. The maxima and minima of temperature fall

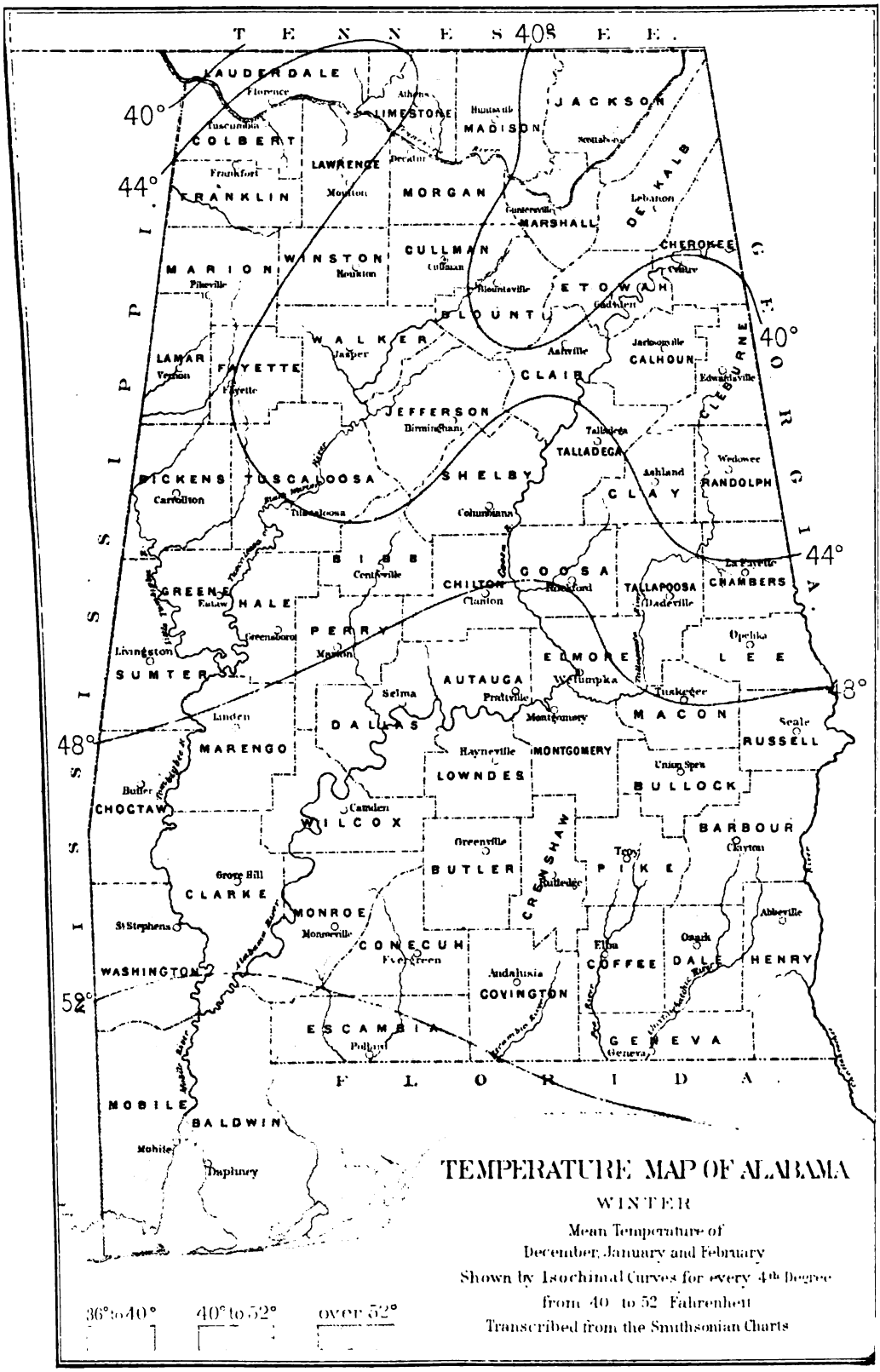
almost without exception in the months of July and January, respectively.

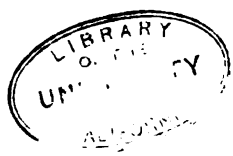
In the lower part of the State, below the latitude of Montgomery, the mean temperature for the winter and for the year are nearly normal; that is, the lines of equal temperature run across the State from east to west, approximately parallel to the lines of latitude, the temperature depending thus almost exclusively upon the latitude. Above Montgomery, however, two things interfere with this regularity, viz: 1. The cooling influence of the mountains, which has the effect of deflecting the isothermals southward. 2d. The heating influence of wide river valleys like those of the Coosa, Warrior, and Tennessee, that are sunk in these highlands. By this cause these lines are carried northward of their normal position.

With these general principles in view, the distribution of the temperature will be readily understood, especially if reference is made to the accompanying maps, which have been prepared from the charts published from the Smithsonian Institute.

The line of mean annual temperature of 68° F. crosses the State just south of Mobile; that of 64°, just above Montgomery, curving, however, southward from Montgomery to Eufaula. The line of 60° follows approximately the curve spoken of as running from Columbus, Georgia, around to the northwestern corner of the State; that is, it follows the borders of the elevated or mountainous region, being however, carried northward by the Coosa and the Warrior rivers and eastward by the Tennessee. The line of 50° is confined to the northeastern corner of the State, but is brought far to the south by the mountain plateau lying between the Coosa and the Tennessee rivers.

The case is similar with the lines of equal temperature for the winter. That of 52° runs nearly parallel with the thirty-first degree of latitude; that of 48° has its normal course through Selma and Montgomery, but is carried by the Coosa river as high up as the crossing of the Selma, Rome, and Dalton railroad at Coosa bridge; and that of 44° follows the margin of the mountainous region, except where it is carried by the Coosa river above Talladega and by the


TENNESSEE
MISSISSIPPI
GEORGIA
FLORIDA
LAUDERDALE
LIMESTONE
MADISON
JACKSON
COLBERT
LAWRENCE
MORGAN
MARSHALL
DE KALB
FRANKLIN
CULLMAN
CHEROKEE
MARION
WINSTON
ETOWAH
BLOUNT
WALKER
CALHOUN
CLEBURNE
LAMAR
FAYETTE
CLAIR
JEFFERSON
TALLADEGA
RANDOLPH
PICKENS
TUSCALOOSA
SHELBY
CLAY
BIBB
CHILTON
COOSA
TALLAPOOSA
CHAMBERS
GREENE
HALE
PERRY
ELMORE
LEE
SUMTER
AUTAUGA
MACON
DALLAS
MONTGOMERY
RUSSELL
MARENGO
LOWNDES
BULLOCK
CHOCTAW
WILCOX
BARBOUR
CRENSHAW
BUTLER
PIKE
CLARKE
MONROE
CONECUH
COFFEE
DALE
HENRY
WASHINGTON
COVINGTON
ESCAMBIA
GENEVA
MOBILE
BALDWIN
40°
44°
48°
52°
TEMPERATURE MAP OF ALABAMA
WINTER
Mean Temperature of
December, January and February
Shown by Isothimal Curves for every 4th Degree
from 40 to 52 Fahrenheit
Transcribed from the Smithsonian Charts
36° to 40°
40° to 52°
over 52°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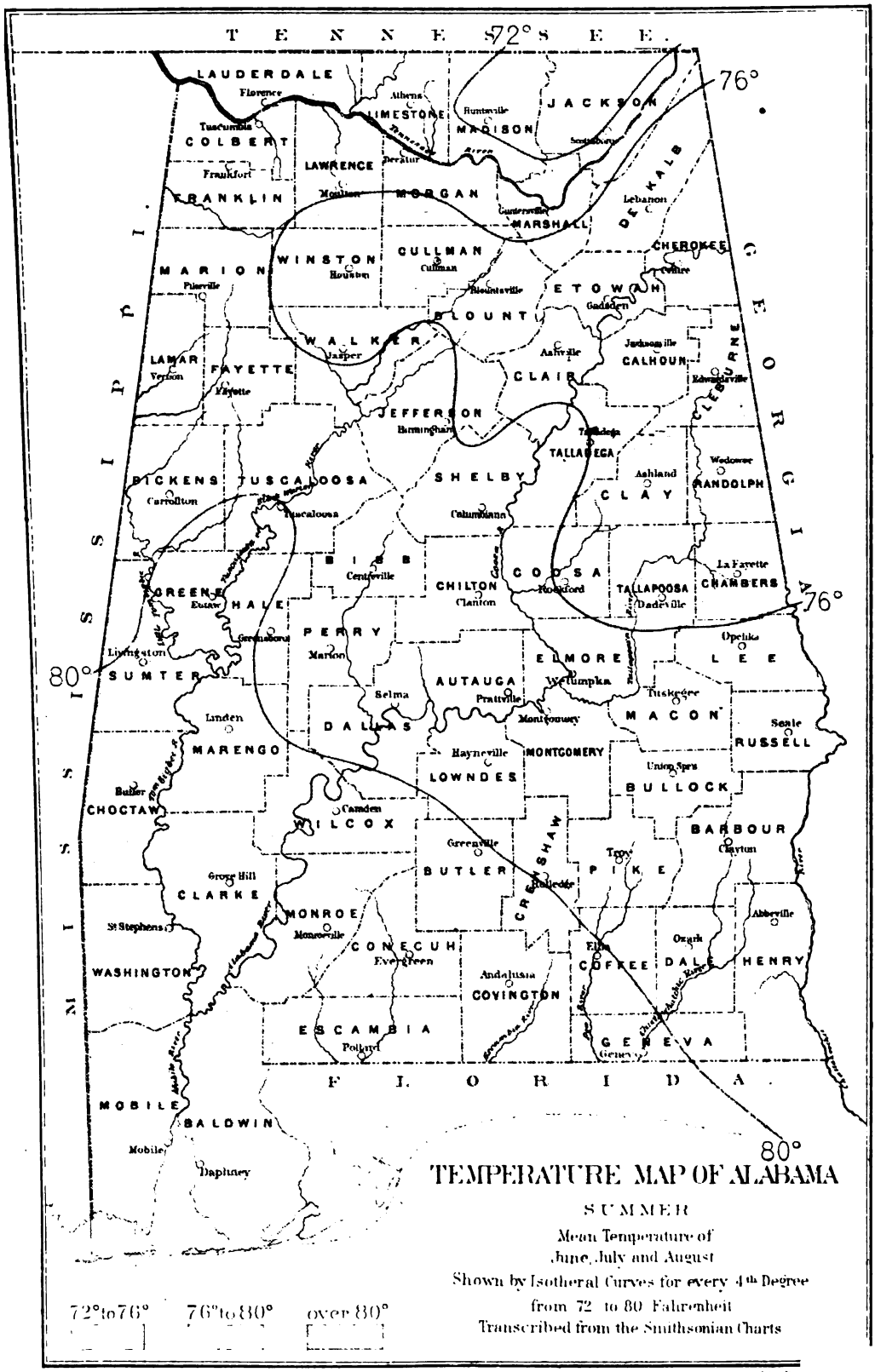
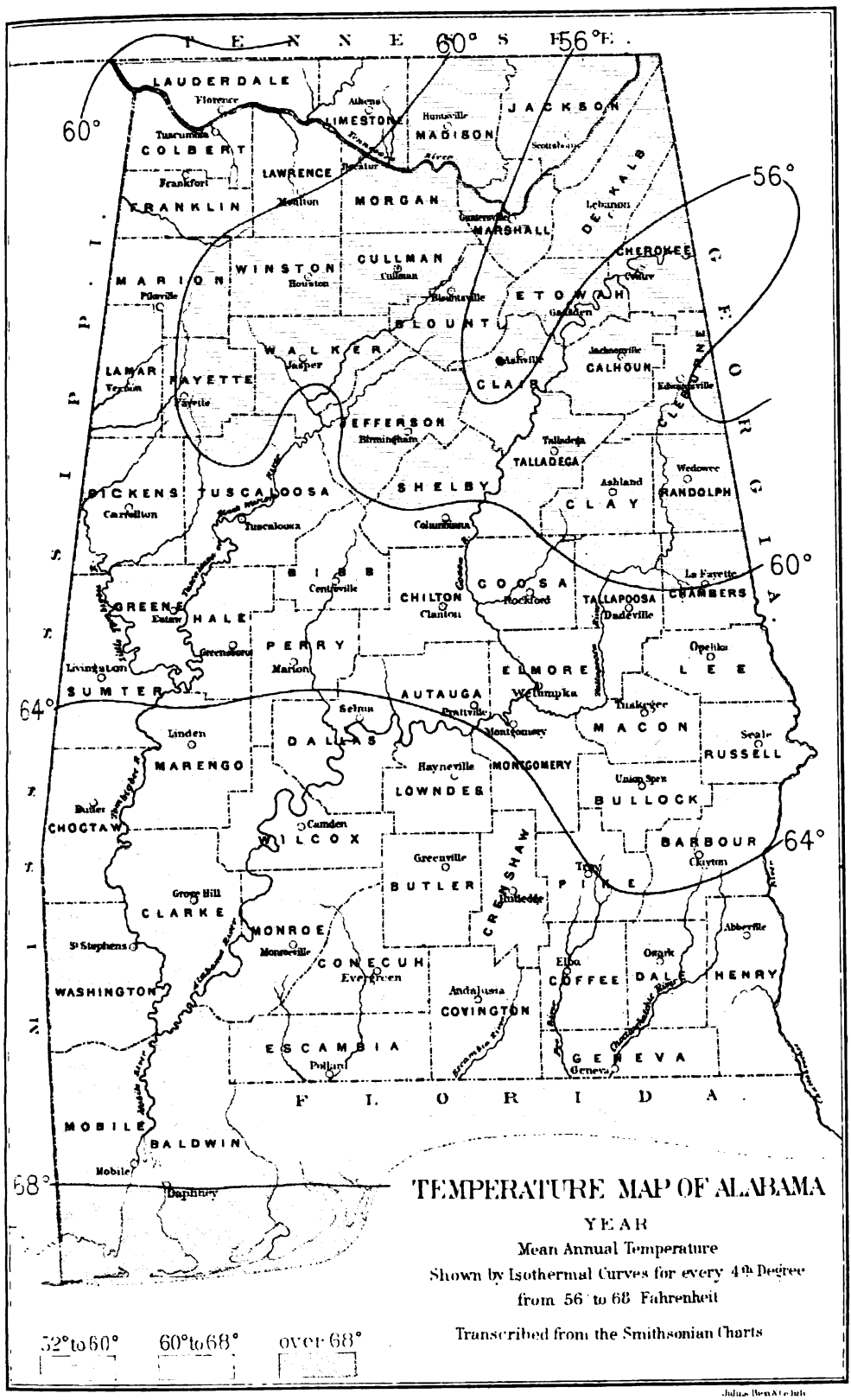

TENNESSEE
72°
76°
80°
MISSISSIPPI
GEORGIA
FLORIDA
LAUDERDALE
Florence
LIMESTONE
Athens
Huntsville
MADISON
JACKSON
Tuscumbia
COLBERT
Tennessee River
Decatur
LAWRENCE
Frankfort
FRANKLIN
Moulton
MORGAN
Guntersville
MARSHALL
Lebanon
DE KALB
CHEROKEE
Centre
MARION
Pikeville
WINSTON
Houston
CULLMAN
Cullman
Blountsville
ETOWAH
Gadsden
BLOUNT
WALKER
Jasper
Jacksonville
CALHOUN
LAMAR
Vernon
FAYETTE
Fayette
CLAY
Ashville
CLEBURNE
Edwardsville
JEFFERSON
Birmingham
TALLADEGA
PICKENS
Carrollton
TUSCALOOSA
Tuscaloosa
SHELBY
Columbiana
Ashland
CLAY
RANDOLPH
Wedowee
BIBB
Centreville
CHILTON
Clanton
COOSA
Rockford
TALLAPOOSA
Dadeville
La Fayette
CHAMBERS
GREENE
Eutaw
HALE
Greensboro
PERRY
Marion
Livingston
SUMTER
Selma
AUTAUGA
Prattville
ELMORE
Wetumpka
Tuskegee
MACON
Opelika
LEE
Scale
RUSSELL
Linden
MARENGO
DALLAS
Montgomery
Haynesville
LOWNDES
MONTGOMERY
Union Springs
BULLOCK
Butler
CHOCTAW
Camden
WILCOX
Greenville
BUTLER
Troy
PIKE
BARBOUR
Clayton
Grove Hill
CLARKE
Claiborne
CRENSHAW
Luverne
Abbeville
St Stephens
MONROE
Monroeville
CONECUH
Evergreen
Andalusia
COVINGTON
Elba
COFFEE
Ozark
DALE
HENRY
WASHINGTON
ESCAMBIA
Pollard
GENEVA
Geneva
MOBILE
BALDWIN
Mobile
Daphney
TEMPERATURE MAP OF ALABAMA
SUMMER
Mean Temperature of
June, July and August
Shown by Isotheral Curves for every 4th Degree
from 72 to 80 Fahrenheit
Transcribed from the Smithsonian Charts
72° to 76°
76° to 80°
over 80°



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Tennessee river eastward nearly to Decatur. The line of 40° includes only the northeastern corner of the State, to which it is crowded by the Coosa and the Tennessee rivers.

The lines of equal temperature for the summer show much greater irregularity, caused apparently by the preponderating influence of the river valleys. Thus the line of 80° runs diagonally from Tallahassee, in Florida, up to Tuscaloosa, by reason of the Alabama, Tombigbee, and Warrior rivers. The line of 78° curves, like some of those above mentioned, around the border of the mountainous region, being considerably indented by the Coosa and Warrior rivers, while it follows the valley of the Tennessee river through the whole of northern Alabama into the State of Tennessee beyond Chattanooga.

In the latitude of Montgomery the last frost occurs, as a rule, between the 5th and the 25th of April, and where the last frost recorded in March the records show that its actual formation in April was prevented by unfavorable conditions, such as cloudy weather or brisk winds. The first frosts occur usually between the 10th and 25th of October. When the first frost falls in November, the records always show that some time in October the temperature was sufficiently low for frost, the actual formation of which was prevented by the unfavorable conditions above mentioned.

The influence of topography upon the formation of frost is clearly seen in those parts of the State where the variations in level are considerable; for though both the mountains and the valleys are exposed to the same conditions, and radiation from each goes on at the same rate, the effects of the radiation will be felt in different degrees. As the air is cooled it becomes more dense, and in consequence flows down the slopes to the lower levels, where it accumulates. The elevated lands are thus never exposed to the full intensity of frosts, for their position affords a ready way for the escape of the cooled air, which flows down the slopes as fast as formed, and the reduction of temperature is in this way greatly retarded.

On the other hand, the valleys and lowlands not only retain all the cold air caused by their own radiation, but serve also as reservoirs for the cold air descending from the

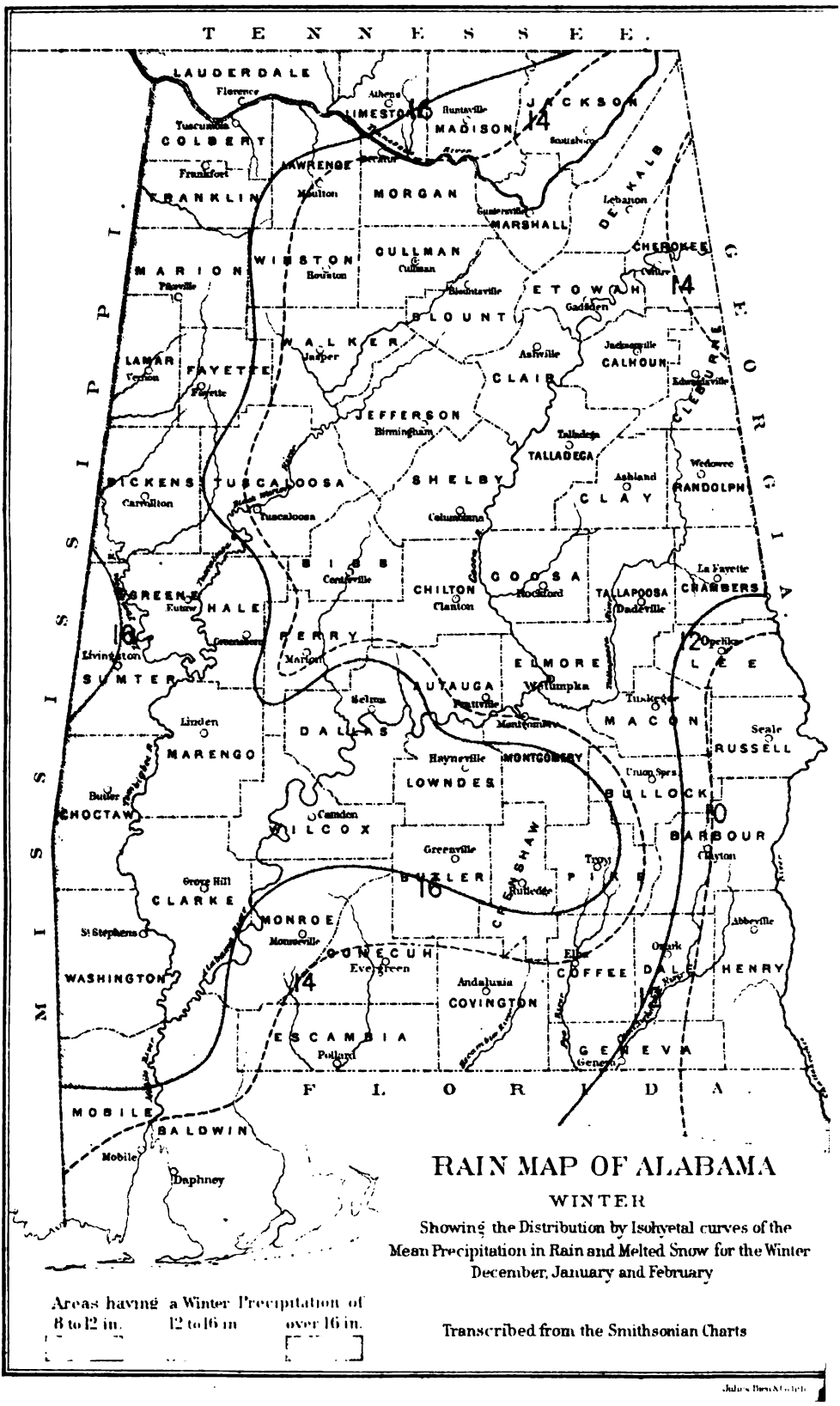
adjoining heights. The conditions for frost formation are thus greatly increased, and in a degree are proportional to the narrowness of the valley and the height of the adjacent hills.

Since the cotton-plant continues to grow and mature its fruit until cut off by frosts, it is obvious that the length of time between frosts becomes an important factor in determining the fitness of a locality for the production of cotton. Hence mountain lands, even with inferior soils, are steadily coming into favor for cotton planting.

Rainfall.—The supply of moisture for the rainfall of the Southern States comes mainly from the Gulf of Mexico, the densest annual precipitation of 60 inches and upward being over the region of the delta of the Mississippi river and along the coasts of Louisiana, Mississippi, Alabama, and western Florida. An area of heavy annual rainfall, 50 inches and upward, spreads thence, with gradually diminishing amount, northward, including Louisiana, southwestern Arkansas, western Tennessee, the whole of Mississippi and Alabama, northwestern Georgia, and parts of middle, western, and southern Florida. Along the eastern coasts of Florida, Georgia, and South and North Carolina the influence of the Atlantic ocean is seen in the heavy precipitate of from 55 to 60 inches which falls there.

The distribution of the rainfall in Alabama for the year, and for the winter and summer seasons, is shown upon the accompanying maps, also prepared from the Smithsonian charts, and is about as follows:

An annual precipitate of 56 inches and upward falls within a belt narrowest in the middle and widening out at both ends, and crossing the State diagonally from the southwestern to the northeastern corner. In the lower part of this belt an area including Mobile and Baldwin and parts of Washington, Clarke, Monroe, Wilcox, Dallas, Lowndes, Butler, Conecuh, and Escambia counties receives an annual rainfall of 62 inches and upward, reaching a maximum of 64 inches at Mount Vernon. In the extreme northwestern corner of the State is another small area whose annual rainfall is above 56 inches. Between these two areas the rainfall is less, falling below 50 inches in the central part. East-



RAIN MAP OF ALABAMA

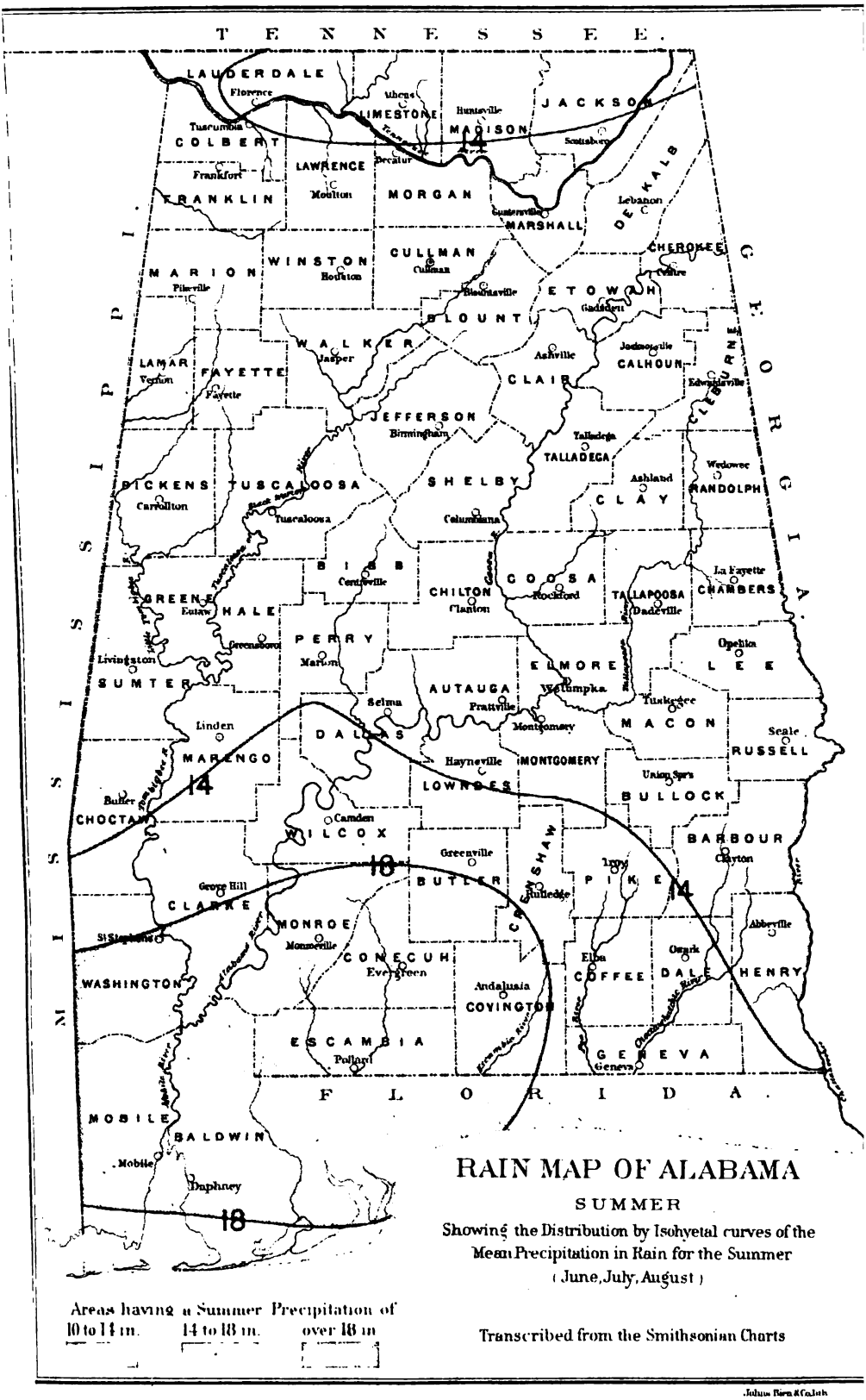
WINTER

Showing the Distribution by Isohyetal curves of the Mean Precipitation in Rain and Melted Snow for the Winter December, January and February

Areas having a Winter Precipitation of

8 to 12 in. | 12 to 16 in | over 16 in.

Transcribed from the Smithsonian Charts



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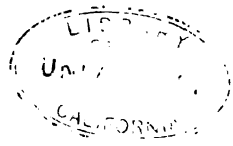

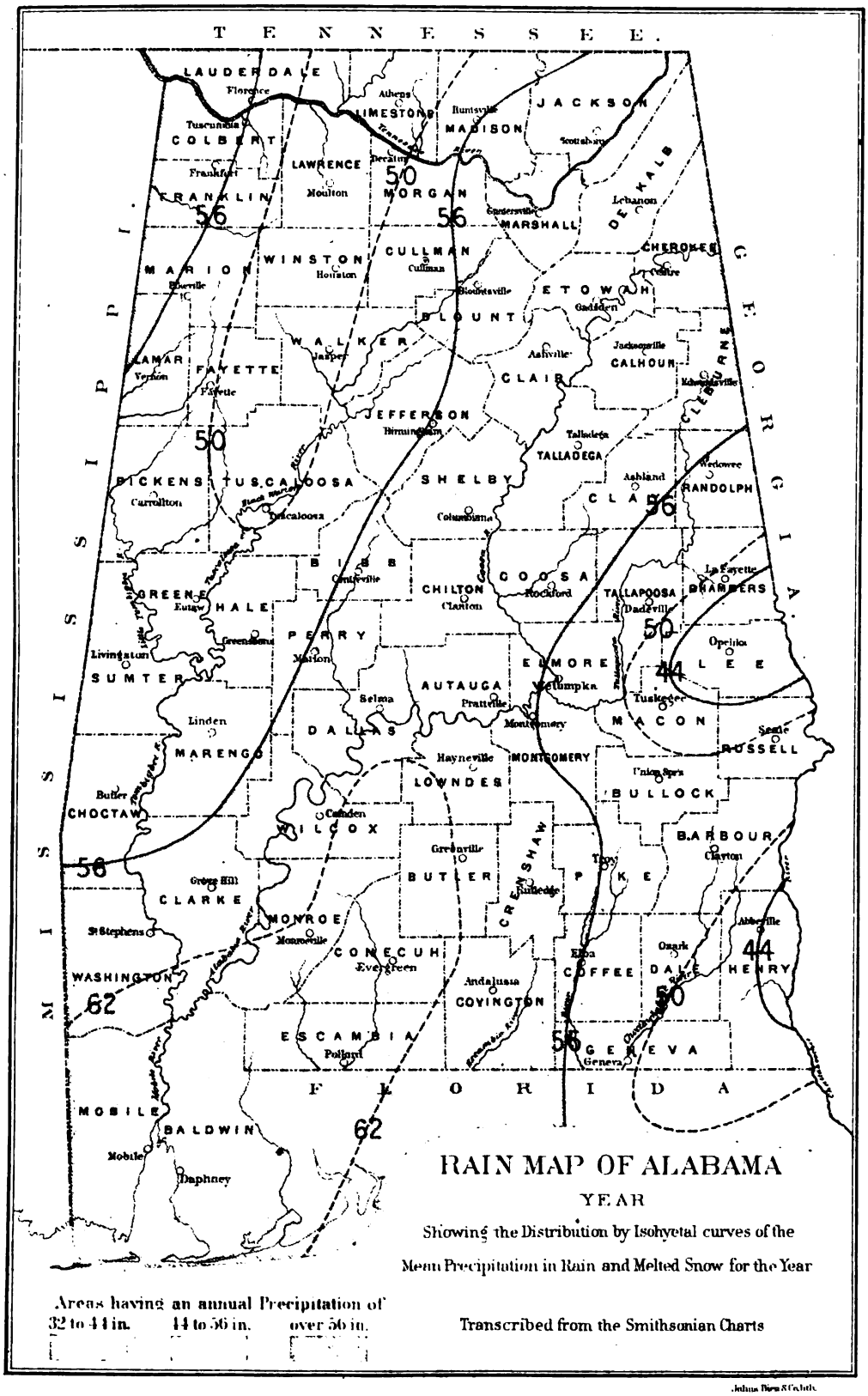

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ward of the main belt the amount of annual rainfall decreases, being between 44 and 56 inches over the southeastern part of the State, except in two small areas in Lee and Chambers and in Henry counties, where it ranges between 40 and 44 inches.

During the winter months (December, January, and February) we find the area of maximum rainfall running along the western border of the State within 30 miles of the Mississippi line, except where a branch is thrown off, including parts of Dallas, Wilcox, Lowndes, Montgomery, Butler, Crenshaw, Pike, and Bullock counties, and another deflection toward the east in the Tennessee valley, including parts of Lawrence, Limestone, and Madison counties. Over the rest of the State the winter rainfall is between 12 and 16 inches, except in a small area in the western part of Sumter county and a strip along the eastern border of the State below Chambers county, including parts of Chambers, Lee, Macon, Bullock, Barbour, Dale, Geneva, and all of Henry and Russell counties, where it falls below 12 inches.

During the summer months (June, July, and August) the greatest amount of rainfalls south of a line running from the southwestern part of Choctaw county to the upper line of Dallas, and thence southward to the southeastern corner of the State, in Henry county. Within the area thus outlined the rainfall is 14 inches and upward, increasing to 18 inches and more in Mobile, Baldwin, Washington, Clarke, Monroe, Butler, Conecuh, Escambia, and Covington counties.

North of the Tennessee river, in Lauderdale, Limestone, Madison, and Jackson counties, we find another area of large summer rainfall, 14 inches and upward, and between the two, over perhaps two-thirds of the State, the summer rainfall falls below 14 inches.

In the meteorological region of which Alabama forms a part there are commonly observed two maxima of precipitation, the principal one about the end of July, the secondary one early in December; also a principal minimum early in October, and a secondary one toward the end of April. The range in Alabama, however, is moderate, and the distribution tolerably uniform throughout the year, as may be seen from the following statement:

The average rainfall of the State is 55.04 inches, and of this 13.86 inches fall during the spring months, 14.07 during the summer, 14.70 during the autumn, and 16.37 during the winter. *(a)*

The records kept at Montgomery show that no periods of wet weather extend over five days, and that when the periods are long heavy rainsfalls are exceptional. During the months of March, April, and May, thunder-storms are not unusual, and the quantity of rain which then falls is sometimes great. These storms come mostly from westerly directions, from southwest around to northwest, but most often from the southwest. The strong winds with which they are usually accompanied sometimes reach the force of hurricanes or tornadoes, which sweep over the country in a narrow track, usually of less than a mile in width. The tornadoes come almost without exception from the southwest, the wind having a gyratory motion, as is shown by the positions of the prostrated trees.

Snow falls occasionally in the months of January and February. In the lower counties of the State it is extremely rare, but northward there is usually at least one considerable snowfall during the winter.

GENERAL TOPOGRAPHICAL AND GEOLOGICAL FEATURES AND DIVISIONS.—Every geological formation occurring in the Appalachian region of North America has its representatives in the stratified rocks of Alabama, and this State therefore possesses a variety in its geology and topography not excelled by any member of the Union.

The main topographical features of any region are either inequalities of surface, caused by actual folds or wrinkles of the earth's crust, or are due to the degradation of the land by atmospheric or aqueous agencies. The two great factors which determine surface configuration are thus seen to be geological structure and erosion. In all cases difference in the quality of the material acted upon as regards resistance to erosion is an important subfactor, to which are due all those minor inequalities which constitute scenery.

a The data for the above account of the climate are derived from the Smithsonian publications.

By atmospheric and other agencies the rocks decay and are disintegrated, crumbling down into soils, which rest upon and vary with the underlying parent rock, or which are removed by running water or other transporting agent and spread over regions more or less remote from their point of origin. A distinction is thus made between transported or drifted soils and those in place. All bottom or alluvial lands are of the nature of drifted soils, but these are always more or less related in composition to the uplands of the particular drainage basin in which they occur. On the other hand, certain parts of the State have been covered in comparatively recent times with transported soils resulting from the commingling of the detritus of widely different geological formations, and often bearing very little relation to the underlying or adjacent rock masses. These, the true drifted soils, exhibit local variations which result from the influence of the underlying rocks upon which they have been deposited.

In the present position of the rock strata, whether approximately horizontal or much inclined, in the nature of the connection between the topography and the geolological structure, and in the relations of the soils to the country rocks upon which they rest, are found the characters according to which, for convenience of study and description of its natural features, the State may be marked off into three tolerably distinct divisions: a middle, a northern, and a southern division.

The Middle Division is the southwestern terminus of a series of folded and faulted strata, which, under the name of the Appalachian chain, extends from the eastern States through Pennsylvania, etc., into Alabama. Throughout this part of the State the strata are usually inclined at considerable angles either toward the southeast or the northwest, and their outcropping edges have the general direction of northeast and southwest. The topographical feature, ridges and valleys, are disposed in parallel strips or belts, having the same direction as rock strata, to which they owe their origin. With the exception of the bottom and alluvial lands, the soils of this division are in place, resting directly upon the rocks from which they have been derived.

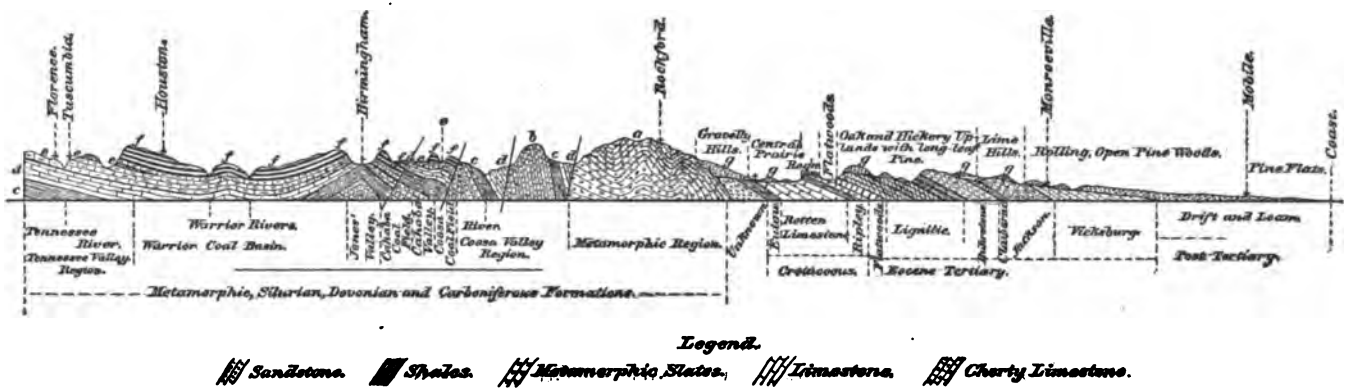
Northwest of this *Middle Division* the southern terminations of the great Cumberland Table-land and of the Highlands of Tennessee extend down into Alabama. These two, together with the Warrior Coal Baisn, constitute the *Northern Division.* Here the strata are approximately horizontal, except along the borders of certain outlying folds belonging to the *Middle Division*, and the influence of geological structure upon the topography is much less distinctly seen than in the preceding division. The soils, like those of the preceding division, and with the exceptions there noted, have been derived from the disintegration of the underlying rocks of the country.

In the *Southern Division*, with approximately horizontal position of the strata, we find the topography very slightly influenced by geological structure, but, on the other hand, almost exclusively the result of erosion, as determined by the differences in the materials of a single formation, the Stratified Drift or Orange Sand, which, except in parts of the prairie belt, covers the underlying beds over this whole division. In this division, therefore, the agricultural features depend, with the principal exception of the prairies, primarily upon the quality of these superficial transported beds, and not upon the rocks of the country. Local modifications of these widely-spread drifted soils, as above stated, are not uncommonly brought about by the influence of the underlying rock masses which they cover.

In the detailed descriptions which follow the divisions are taken up in the order above given, which is also the order of their relative geological ages.

The relations above mentioned are shown by the following general section across the State along the broken line, specified below:

Fig. 1. General section across the State of Alabama from Florence, *southeastward* through Tuscumbia, Houston, and Birmingham to Rockford, Coosa county, and thence *southwestward* through Monroeville, Monroe county, and Mobile to the Gulf coast, showing the disposition of the geological formations and the geographical positions of the agricultural regions, together with their relations to the geological formations.



Explanations.—*a.* Mountains of the *Metamorphic region.* *b.* Sandy mountain lands—*Potsdam* and *upper sandstone.* *c.* Red valley lands of the *Shale* and the lower part of the *Magaesian Limestone.* *d.* Loams and cherty gravelly ridge lands based on the *Magnesian Limestone;* and brown loam lands of the *Trenton Limestone.* *e.* Brown loams and cherty ridge lands based chiefly on *Sub-Carboniferous limestones.* *f.* Sandy lands of the *Coal Measures.* *g.* Pebbles, sands, and loams of the *Stratified Drift* overlying chiefly the newer formations of the State, but overlapping also the older formations and concealing the line of junction of these and the newer.

AGRICULTURAL SUBDIVISIONS OR REGIONS.—Under these general divisions the agricultural features of Alabama will be described in the following order:

MIDDLE DIVISION.

1. The *Metamorphic region*, including—
   Red Lands.
   Gray Lands.
2. The *Coosa Valley Region*, with its—
   Flatwoods.
   Brown-loam and Red-clay Lands.
   Gray Cherty Lands.

There are also included in this division the Coosa and Cahaba coal-fields, but they are described in detail under the succeeding head.

NORTHERN DIVISION.

3. *Coal Measures region*, including the sandy lands of—
   The Coosa and Cahaba coal-fields.
   The Warrior basin and plateau.
4. *The Tennessee Valley region*, the three subdivisions of which are—
   Barrens.
   Red Valley Lands.
   Sandy lands of Little Mountain range.

SOUTHERN DIVISION.

5. *Oak and Pine Uplands region*, which includes—
   Oak and Hickory Uplands, with Short-leaf Pine.
   Gravelly Hills, with Long-leaf Pine.
   Oak and Hickory Uplands, with Long-leaf Pine.
   The latter still further sub-divided into—
   Brown-loam Uplands, and
   Pine Hills.
6. *Upper or central prairie region*, including—
   Black Prairie or "Canebrake."
   Hill Prairies and Chunnenugga Ridge.
   Blue Marl Lands.
7. *Post-oak Flatwoods belt or region*, including—

8. *Lower Prairie region, or Lime-hills.*
9. The *Long-Leaf Pine region*, sub-divided into—
   Rolling, Open Pine Woods, with Lime-sinks.
   Pine Flats.
10. *Alluvial region* of Mobile river and the coasts.

SECTION II.

A DETAILED DESCRIPTION, ACCOMPANIED BY ANALYSES OF SOILS, MARLS, ETC., OF THE SEVERAL AGRICULTURAL REGIONS OF ALABAMA; TOGETHER WITH REMARKS ON COTTON PRODUCTION, AND UPON THE FERTILIZERS NATURALLY OCCURRING IN THE STATE.

MIDDLE DIVISION.

A line drawn on the map from the northeastern corner of the State southwestward to Tuscaloosa, and thence through Centreville, Clanton, Wetumpka and Tallassee to Columbus, Georgia, would mark approximately the boundaries of this division.

A part of the Coal Measures of the Warrior field, though falling within the limits above given, is to be classed with the next division, and, on the other hand, Murphree's and Brown's Valleys, in Blount and Marshall counties, and the continuation of the last-named valley northeastward along the Tennessee river through Jackson county, though outside these limits, is still to be included in this division, which, as thus defined, has an area of nearly 10,000 square miles, and embraces the following counties and parts of counties: All of Cleburne, Calhoun, Saint Clair, Shelby, Talladega, Clay, Randolph, Chambers and Coosa, narrow belts through Jackson, Marshall, DeKalb and Blount, southern Cherokee, most of Etowah, southeastern Jefferson, a small strip along the southeastern edge of Tuscaloosa, northern Bibb, eastern half of Chilton, southern Elmore, Tallapoosa and Lee.

SUBDIVISIONS.—By reference to a geological map of the State, it will be seen that this division includes: 1. The

Metamorphic region. 2. The Valley of the Coosa, together with its outliers, the Cahaba, Roup's, Jones', Wills', Murphree's and Brown's Valleys, and the continuation of the latter along the Tennessee river to the northeastern corner of the State. 3. The Coosa and the Cahaba Coal-fields.

These three subdivisions are best described separately.

The Metamorphic Region.

This being a part of the great Appalachian chain, includes some of the most elevated land in the State in the counties of Cleburne, Randolph, Chambers, Lee, Macon, Tallapoosa, Clay, Coosa, Elmore and Chilton, comprising an area of 4,425 square miles.

Geological Characters.—The rocks of this region are the altered and crystalized sediments either of Silurian or preceding ages, and exhibit the greatest diversity, both in their chemical composition, in their physical characters, and in the nature of the topography and the soils to which they give rise. There are all gradations between the hard, almost indestructible quartzites to the easily-eroded marble; from the warm, fertile and undulating granitic and gneissic land to the much broken, often sterile tracts formed by mica slates and other highly siliceous rocks. With the varying composition of the rocks come varying degrees of resistance to decay and erosion, and hence the great variety in the scenery of this region, where high and almost mountainous ridges alternate with rolling and sometimes rugged lowlands and valleys. In some parts, the strata have undergone complete disintegration in place, and have been converted into great masses of stratified clays, interlaminated with seams of quartz, which, gradually broken down, cover the ground with their angular fragments.

Soils.—The depth to which this decay reaches depends on the nature of the rock and its position, and in many instances even twenty or thirty feet below the surface the rock is still much decomposed. At the surface, a loam with not much appearance of stratification overlies the decayed slates to the depth of several feet in valleys, but much less along the slopes and on the summits. This loam forms the soils and subsoils, which are thus seen to be in most cases

directly related to the underlying beds. These soils and subsoils have all probably been slightly shifted from their original place, especially in the valleys, but seldom to that distance where their relationships cannot be readily traced to the underlying or immediately adjacent rock masses.

The two principal soil varieties commonly recognized by the farmers are those which make the gray and the red lands respectively. Of each of these, however, there are numerous subvarieties, exhibiting all grades of color and of fertility. The gray lands may be derived from felspathic rocks, such as granite and gneiss, in which case they are often quite fertile, or from silicious mica slates or other quartzose rocks, when they may be almost barren. Similarly, the red lands, when derived from feldspathic rocks, such as hornblendic gneiss, etc., rank high in productiveness, while those resulting from the decay of certain mica or clay slates, bearing garnets or other ferruginous minerals, frequently lie at the other extreme. In the present state of our knowledge it is impossible to mark with accuracy the localities where these several soil varieties occur throughout the metamorphic region; but what can at present be said concerning their occurrence will be found under the head of each county.

Of the true gray granitic (feldspathic) soils there is only a limited area in this State, but a belt of this kind of land passes through Rockford and Bradford, in Coosa county. It is seen again near Blake's ferry, in Randolph, and near Louina, in the same county; then near Milltown, in Chambers county. Indeed, the granite itself, so far as it has yet been observed, passes everywhere, by insensible gradations, into a schistose or stratified rock, or into gneiss, and thus our granitic soils might more properly be classed as gneissic throughout. No analyses of soils from those localities where the so-called granite makes the country are at hand.

The gneisses vary in composition from granitic gneiss to mica-schist, which contains only quartz and mica, and vary in fertility in a corresponding degree. On the other hand, variations brought about by an intermixture of iron-bearing minerals, such as hornblende, garnets, etc., are seen in the hornblendic gneisses and other similar rocks. Throughout

the region of occurrence of the gneissic rocks the variations of soils, produced in the manner alluded to, are so numerous, and follow each other in so irregular a manner, as to defy classification and localization, except in the most general way. Thus, it may be said that the gneisses (with all their variations) are of more frequent occurrence in the southeastern half of the metamorphic region, while the more siliceous and argillaceous or clayey rocks prevail, as a rule, in the northwest. Still, such a statement expresses only the most general relations, for rocks of all kinds occur in both divisions.

Of the two principal soil varieties above named, that of the *red lands* is derived from the decomposed hornblendic gneisses and slates, which in many places, where exposed in washes or gullies, are seen to be mere stratified clays, containing fragments more or less angular of the quartz veins or seams which are nearly always interbedded with the other rocks of this region. This red soil (the color of which comes from the iron of the hornblende) is considered best adapted to the production of corn and other grains. Its natural growth consists of the various species of oaks (white, post, Spanish, red, and a few black-jacks), hickory, poplar, and some shortleaf pine, especially where the red and gray soils overlap, making mulatto-colored soils. The top stratum of this soil, from two to three inches in depth, has often a dark chocolate-brown color, but below it becomes a brighter red, and at varying depths, from ten to fifteen feet, becomes a yellowish hard clay. Where the freshly decomposed rocks are seen the color is yellowish rather than red, the latter color being darker and more intense apparently the further removed the soil is from its original position and the more it is affected by the decay of the vegetable matter. When first cleared, these lands were thought to be the best in the country, and many fine farms are still found upon them. The majority of the farmers now, however, seem to prefer the gray soil, as being more certain, more easily tilled, and even more fertile. The red lands were the first to be cleared up by the original settlers, and most of the older farms and fine old country residences are upon this kind of land.

The *gray soils* result from the disintegration of gneisses

and mica slates, which contain comparatively little or no hornblende or other iron-bearing minerals. They are commonly somewhat sandy, usually light-colored, gray to dark gray, sometimes nearly black, with very often, however, a decidedly reddish color similar to that of the hornblendic soils above described. Fragments of the partially decayed gneiss of a light-gray color often lie embedded in reddish and even red clays or clayey sands. These gray soils are easily tilled, are certain of crop even with moderately favorable seasons, and are better suited than the red to the culture of cotton. Below some three or four inches of dark gray sandy top soil there is usually a lighter colored but somewhat yellowish subsoil. The timber is much the same as that upon the red lands, viz: oaks and hickory, with a few short-leaf pines.

The subjoined analyses will show the chemical characters of these two soil varieties:

No. 78. *Red land soils* from six miles north of Opelika, Lee county (S. 16, T. 20, R. 27 E.). Depth, eight inches; vegetation, red, Spanish, and post oaks, hickory, and a few short-leaf pines; color dark red.

No. 79. *Gray gneissic (isinglass) soil* from six miles north of Opelika, Lee county (S. 17, T. 20, R, 27 E.). Depth, eight inches; vegetation, red, Spanish, and post oaks, hickory, and a few short-leaf pines; color, grayish-brown.

GNEISSIC SOILS, LEE COUNTY.

	RED LAND SOILS.	GRAY LAND SOILS.
	No. 78.	No. 79
Insoluble matter	68.710	79.170
Soluble silica	3.830	72.540	3.250	82.426
Potash	0.350	0.268
Soda	0.119	0.067
Lime	0.043	0.167
Magnesia	0.050	0.130
Brown oxide of manganese	0.100	0.093
Peroxide of iron	10.749	3.044
Alumina	9.237	5.120
Phosphoric acid	0.170	0.229
Sulphuric acid	0.080	0.043
Water and organic matter	7.019	7.742
Total	100.440	99.429
Hygroscopic moisture absorbed at	7.40 27.8 C.°	4.54 26.7C.°

Of these two soils, in proportion to the amount of insoluble matter, the gray is decidedly better, in respect of potash, phosphoric acid, and lime, and is probably more thrifty. The red soil is rather deficient in lime, but in rententiveness of moisture it is superior to the other. Both are fairly good soils.

Running northeast and southwest through the metamorphic area near the southern border there is a belt of varying width, in which hydromica slates, often highly graphitic, are of frequent occurrence. These mica slates are usually filled with garnets, are much decomposed, and alternate with thin beds of clay slate, which is occasionally so highly graphitic as to be used as lubricating material. In Randolph and Tallapoosa counties these rocks are found abundantly, and details of their occurrence will be found under those headings. The soil derived from these rocks is of yellowish-gray color, finely pulverized, and supports a growth of the usual upland character.

Mica slates containing the common micas, such as muscovite and biotite, are also of frequent occurrence, and the soils yielded by them are also of varying degrees of fertilty, being between a first-rate gneissic soil, on the one hand, and a poor sandy material on the other. These variations have already been the subject of remark under the heading of the gneissic soils.

As to the distribution of these mica slates no general rule can be given, since they alternate in so many ways with the other metamorphic rocks. The following analyses are probably fairly characteristic of these two varieties:

No. 107. *Mica slate soil* (graphitic, hydrous mica) from four miles north of Roanoke, Randolph county. Depth, eight inches; vegetation, black, red, post, and black-jack oaks, with a few short-leaf pines and hickories; color, light-yellow.

No. 103. *Mica slate soil* (garnetiferous, common mica) from S. 27, T. 19, R. 7 E., Clay county. Depth, eight inches; vegetation, black, red, and Spanish oaks, with a few hickories and chestnuts; color, buff-yellow, passing downward into orange. The subsoil is a tolerably stiff red clay.

MICA SLATE SOILS.

	RANDOLPH COUNTY.		CLAY COUNTY.	
	Mica slate soil (graphitic, hydrous mica).		Mica slate soil (garnetiferous, common mica).	
	No. 107.		No. 103.	
Insoluble matter	77.354	81.340	66.174	75.437
Soluble silica	3.986		9.263	
Potash		0.536		0.351
Soda		0.086		2.246
Lime		0.010		0.038
Magnesia		0.145		0.155
Brown oxide of manganese		0.146		0.151
Peroxide of iron		6.861		9.303
Alumina		5.693		8.083
Phosphoric acid		0.067		0.137
Sulphuric acid		0.057		0.090
Water and organic matter		4.772		5.706
Total		99.713		99.697
Hygroscopic moisture		4.612		5.91
absorbed at		7.2 C.°		6.1 C.°

Both these soils are deficient in lime, and No. 107 is also deficient in phosphoric acid. The rock from which No. 107 is derived has usually been called "talcose slate", but a full analysis shows that it contains only a small percentage of magnesia. Soils like No. 107 are quite common throughout the "gold regions", which, as is well known, does not rank as the best farming country. The rock from which No. 103 is derived contains the ordinary mica, and is filled with garnets of large size, often as much as two inches in diameter. This soil is fairly productive in good seasons, but cannot stand much dry weather, and, being rather light, soon wears out. It is a good representative of the better class of mica slate soils, and does not exhibit the sterility characteristic of some of them, especially those derived from a mica slate of a purple color running through Cleburne, Clay and Coosa, into Chilton county, and which are almost barren, supporting a growth consisting almost entirely of stunted long-leaf pines and black jacks.

A comparison of the four analyses just given, shows that the soils may be divided into two general classes, viz:

sandy and clayey or loamy. To the first belong the two gray soils, *i. e.*, the gneissic and the hydromica; to the second, the red soils, *i. e.*, the hornblendic and the mica slate; and, in the most general terms, the soils of this region are usually grouped under one or the other of two heads, as sandy or gray and as loamy or red soils. In some rare instances we have loamy or clayey soils which are deficient in red coloring matter, but as a general thing the clayey and the ferruginous matters are closely associated.

This close agreement of the soils in composition, though derived from rocks of different kinds, bears out what was said concerning the relations between the different rocks themselves; for since the great majority of the rocks of this region may be classed with the gneisses, and as these vary in the one direction, by the accession of hornblende or other iron bearing minerals, through hornblendic gneisses to almost purely hornblendic slates, so the corresponding soils pass from light-grayish colors through the various grades of yellow to deep red; and since the increase in the amount of hornblende is usually attended with a decrease in the amount of free quartz or silica, it is easily seen that these soils are less and less distinctively sandy as they pass from light to red colors.

Variations in the gneisses take place in another direction by the gradual disappearance of the feldspar and the corresponding increase in the proportion of quartz and mica, as when the gneiss passes into mica slate. In this series the light-colored feldspathic soil gradually loses its fertility, becoming more sandy and sterile till the sandy micaceous soils of the typical mica slates are reached. No analyses are yet on hand of the clay slate soils.

The Coosa Valley Region and its Outliers.

The wide valley, with prevailing calcareous rocks, which lies between the Metamorphic area on the one hand and the southeastern edges of the Coosa and Cahaba Coal-fields and Lookout Mountain on the other, has received the name above given from the Coosa river, which traverses its whole length. Geologically, it is the continuation of the Valley of Eastern Tennessee; and, indeed, the valley of which this is

a part, and which has been described by Professor Safford as a complex trough, fluted with scores of smaller valleys and ridges, extends at least from the Susquehanna river to middle Alabama.

The main Valley of the Coosa, with the limits above given, is from fifteen to twenty or thirty miles wide, and is furrowed with parallel valleys and ridges, all trending northeast and southwest. This valley is embraced in the counties of Cherokee, Cleburne, Calhoun, Etowah, Saint Clair, Talladega, Shelby, Coosa and Chilton, and has an area, including its ridge lands, of 2,580 square miles. Several outlying valleys, with very similar geological structure and soil varieties, may be most conveniently described in connection with it.

These outliers are: 1. The Cahaba Valley, lying between the Coosa and Cahaba Coal-fields, in the counties of Saint Clair, Jefferson, Shelby and Bibb, its area being 385 square miles. 2. Roup's and Jones' Valley, between the Cahaba and Warrior Coal fields, in Jefferson, Tuscaloosa and Bibb counties; area 285 square miles. 3. Wills' Valley, between Lookout and Sand Mountains, in DeKalb, Etowah and Saint Clair counties; area 460 square miles. 4. Murphree's Valley, in Etowah and Blount counties; area 110 square miles. 5. The Blount Springs or Brown's Valley, which is a prolongation into Alabama of the Sequatchie Valley of Tennessee, and runs through Jackson, Marshall and Blount counties, having an area of about 460 square miles.

GEOLOGICAL FORMATIONS.—The strata which appear at the surface and contribute to the formation of the soils in all these valleys, are the representatives of all the geological formations occurring in Alabama, from the Primordial or lowest division of the Lower Silurian up to the base of the Coal Measures. In the following statement is given, in descending order, the names and geological positions of these strata, so far as their equivalence has been made out:

Carboniferous.....	7. Coal Measures of the Warrior, Cahaba and Coosa fields.
Sub-Carboniferous	6. Upper Calcareous, Mountain Limestone.
	5. Lower Siliceous, Siliceous group.
Devonian.....	4. Black Shale.

Upper Silurian....	3. Clinton or Red Mountain group.	
Lower Silurian....	2. Trenton and Chazy shales and limestones.	
	1. Calciferous and Potsdam.	*e.* Dolomite or magnesian limestone.
		d. Shale (calcareous shales).
		c. Upper sandstone (calcareous sandstone).
		b. Potsdam sandstone proper.
		a. Semi-metamorphic shales and conglomerates.

The lithological and other characters of these different formations, so far as they are of importance from an agricultural point of view, will be given in the special description of the soils.

COOSA VALLEY.

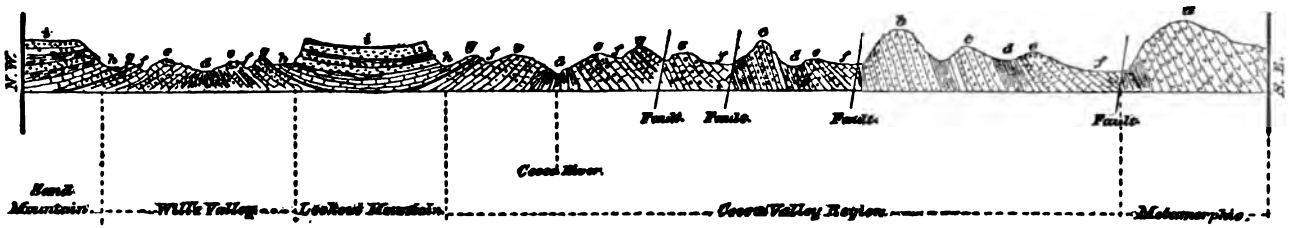
Under this name is included that belt of thirty or forty miles width east and west lying between the Metamorphic area on the one hand and the Coal Measures on the other, and extending from the eastern border of the State, in the counties of Cherokee and Calhoun, southwestward for one hundred and twenty miles.

With reference to these mountainous borders, it may be considered as one valley, but in reality it consists of several parallel valleys separated by ridges of greater or less height. The highest of these ridges are found in the southeastern part of the valley, where they attain true mountainous proportions.

The structure of the Coosa Valley region, as well as that of an outlying anticlinal valley, will be easily understood by an examination of the accompanying figure, which represents a section from Sand Mountain, across Wills' Valley, Lookout Mountain, and Coosa Valley, to the mountains of the Metamorphic region. The section is taken from northwest to southeast, at right angles to the general direction of the strata, and the figure does not pretend to give the minute details of structure, but only its broad outlines, and it is, therefore, in great degree diagrammatic.

FIGURE 2.

Section from Sand Mountain, on the northwest, to the Metamorphic region on the southeast, showing the geological structure of the Coosa Valley region, Lookout Mountain, and an outlying anticlinal valley (Wills').



EXPLANATION.—*a.* Mountains of the *Metamorphic region.* *b.* Sandy mountain lands—*Potsdam Sandstone.* *c.* Ridgy lands of the *Upper Sandstone.* *d.* Red valley lands of the *Shale* and the lower part of the *Magnesian limestone.* In the Coosa River region and central parts of Wills' Valley, the shale forms "flatwoods." *e.* Loams and cherty gravelly ridge lands, based on the *Magnesian limestone.* *f.* Brown loams of the valleys, based on *Trenton limestone.* *g.* Red ore ridges; *Silurian* sandstones and ore on one side and *Sub-Carboniferous* cherty limestones on the other. The cherty gravel covers the side next to the Coal Measures. *h.* Brown loams of the valleys, based on *Sub-Carboniferous* limestones. *i.* Sandy lands of Lookout and Sand Mountains, *Coal Measures.* The sandstones etc., of Coal Measures form the borders of the anticlinal valleys.

The structure of the Coosa Valley varies with the locality. From the Georgia line down to Gadsden, it consists of two parts, the western being a large anticlinal, and the eastern being formed of strata repeated by faults. The eastern side of the anticlinal is itself cut short by a fault. Below Gadsden the anticlinal turns westward from the river, and is merged into Jones' Valley, while the Coosa Valley proper is altogether within the area of the faulted series.

The figure, taken together with the lithological and topographical characters given in connection with the special description of the soils, will show very clearly the part borne by each formation in the production of the topographical features of this valley. It will be noticed that the ridges are of four kinds, viz: in the anticlinal, the Red Ore ridges, usually steep, with chert fragments on one side and sandstone and limestone on the other; the ridges of the Dolomite, rounded and covered with masses of chert. In the eastern part of the Coosa Valley the ridges are the chert ridges of the Dolomite, the sandstone ridges of the Upper Sandstone, steep and sharp-crested, but not high, and lastly, the mountains of Potsdam Sandstone.

The valley-making formations are the Sub-Carboniferous in part, the Trenton and Chazy, the calcareous parts of the Dolomite, and the Shale. The first of these (Sub-Carboniferous) is found only in the anticlinal part of the valley; the others are found in both parts. The immediate valley of the river as far south as Gadsden is underlaid by the shales, covered, however, in great measure with the sands and pebbles of a later period. The Dolomite, as usual, forms the greater part of the superficial area of the ridgy valleys on each side of this central portion, and, from an agricultural point of view, is perhaps the most important formation. (*a*)

OUTLIERS OF THE COOSA VALLEY.

Cahaba Valley.—This valley lies between the Coosa and Cahaba Coal-fields. In its geological structure it resembles the eastern part of the Coosa Valley, for a fault on its west-

a In the figure the Dolomite does not occupy its proper proportion of the area.

ern edge brings the upper sandstone up to the level of the Cahaba Coal Measures, and going thence eastward we pass, in ascending order, over the following strata: Upper sandstone, the Shale, the Dolomite, Chazy and Trenton, Clinton, Black Shale, Sub-Carboniferous, and Coal Measures (Coosa field). As in other cases, the greater part of the area of the valley is made by the strata of the Magnesian limestone or Dolomite.

Roup's and Jones' Valley.—These names are given to the two ends of the valley lying between the Cahaba and the lower part of the Warrior field, merging into the Cahaba and Coosa Valleys above Springville.

Wills' Valley, Murphree's Valley, and Brown's Valley.—There are troughs sunk in the Coal Measures of the northeastern or plateau division of the Warrior field. In structure, these are all, with the exception of the Cahaba Valley above described, anticlinal folds in the Warrior Measures, furrowed out subsequently by erosion. While the floors of these valleys are much lower than the rims which bound them (for the folding involved also the strata of the Coal Measures for a short distance on each side), they are, nevertheless, considerably higher than the synclinal basins of the Coal Measures, between which they lie, and for that reason water rising in these valleys sooner or later breaks through the moutain rim and flows off into the streams which drain the basins.

Exceptions to this general statement are found in what has been termed the plateau region of northeastern Alabama, and an examination of the map will show that the tributaries of the Tennessee in Marshall and DeKalb counties rise on the plateau near the edge of Wills' Valley, flowing down and across the plateau, while the streams rising in the valley flow along it to each end of the same and do not break across the Coal Measures on either side.

The section (Fig. 2), p. 193, represents in a general way the geological structure of all these valleys, and shows with sufficient distinctness the parts borne by each of the formations appearing in them, determining their topography, the remarks under the Coosa Valley applying here also. The structure is, however, especially in the southwestern part of

this region, rarely so simple as is represented in the section, for the anticlinal fold has, in some cases, been thrust or lapped over toward the northwest, thus causing some of the more recent formations to lie beneath the older, and in addition to this, by reason of a fault or break in the strata, the red-ore ridge on the western side of the valley has been duplicated. This duplication of the Red Mountain is characteristic of the valley from the upper edge of Tuscaloosa county nearly through Jefferson. On the western side of the valley also the strata are usually very nearly vertical, and a very prominent ridge is made by the thick bed of a conglomerate which lies at the base of the Coal Measures. At a short distance from this ridge the strata of the Warrior Measures have their usual nearly horizontal position.

The red-ore ridges are commonly of very unequal size on the two sides of the valleys, rising to the dimensions of small mountains on one side, while on the other they are so insignificant in size as to be often overlooked entirely.

SOILS OF THE COOSA AND OUTLYING VALLEYS.—Classified according to color and general physical characters, the soils occurring in these valleys are either red or brown loams derived from the pure calcareous formations, such as parts of the Shale, the Dolomite, Trenton, and Sub-Carboniferous; or lighter colored to gray siliceous soils, usually filled with angular, flinty gravel, and resting on a Yellowish clayey subsoil derived from cherty limestones of the Dolomite and of the Sub-Carboniferous; or the light sandy loams which result from the disintegration of sandstones such as make up the greater part of the Potsdam proper, the Upper sandstone, and the Coal Measures. But since the soils of each of these classes vary according to the geological formation to which they owe their origin, their discussion in connection with these formations will best bring out their peculiarities of composition and explain their distribution in the valleys.

Acadian Slates and Conglomerates.—These have received notice under the preceding division, since they are more or less metamorphosed and cystalline in texture, and are otherwise closely associated with the true metamorphic rocks.

Potsdam Sandstone.—The principal rock of this group has already been mentioned as a rather coarse-grained sandstone, and hence the resulting soil is sandy. In many places the soil is thin and vegetation scanty and stunted, but occasionally the growth is vigorous, consisting of the upland oaks, chestnut, and short-leaf pine. By reason of the mountainous character of the country, made by these rocks, very little of this soil is under cultivation, but there are many spots of good grazing ground. The Potsdam sandstone, in a series of outlying mountains forming an interrupted chain, skirts the western border of the Metamorphic region and extends through the counties of Cherokee, Calhoun, and Talladega.

Upper Sandstone.—The soils derived from this formation are usually somewhat calcareous, though sandy, but the sharp-crested, steep ridges to which they are confined are seldom under cultivation. The entire thickness of the formation is inconsiderable, and as the strata usually lie tilted at high angles the superficial area occupied by them is quite limited. Isolated ridges of these rocks are found in the Coosa Valley, in the counties of Cherokee, Calhoun, and Talladega, and in the Cahaba Valley in Shelby and Saint Clair counties. Besides these occurrences, the mountains of Potsdam sandstone, above described, have usually a narrow border of these rocks on their eastern slopes.

The Shale.—This formation in its outcrops presents two well-marked phases. Its lower beds are mostly shales, which, at the surface, have been thoroughly leached of calcareous matter, and generally break up into small fragments having very much the appearance of shoe-pegs. The colors of these shales are chocolate-brown, red, greenish, and gray. The soils formed from these materials are usually thin, and, though considered productive in good seasons, are liable to injury from drouth. The timber is a mixture of chestnut, red, and white oaks, dogwood, and hickory. The valleys occupied by these variegated shales are ridgy, the shale ridges being often almost bare of soil. Areas of these shales are usually associated with the outcrops of the Upper sandstone, with the upper strata of which they are closely related lithologically, and characteristic occurrences

are not unfrequent in Bibb county, northeast of Centerville, near Pratt's Ferry, in the vicinity of Montevallo, and Helena, in Shelby, and along the southeastern flanks of the isolated ridges of the Upper sandstone and the mountains of Potsdam sandstone in Talladega, Calhoun, and Cherokee counties.

The upper strata of the formation, on the other hand, are frequently thin sheets of limestone, alternating with seams of clay and with thin beds of sandy and aluminous shales. These beds often occupy the central parts of the anticlinal valleys as a mass of greatly contorted, usually nearly vertical strata, of which the thin-bedded limestone forms the greater part, the shales and clay being mostly weathered out, giving rise to a stiff clayey soil, through which the edges of the limestone protrude.

Flatwoods.—Where the clayey portions predominate and the drainage is defective level tracts are formed which are known as "flatwoods", and which are usually uncultivated, though the timber indicates a soil by no means sterile. The prevailing timber of the flatwoods is post oak and short-leaf pine. The soils are usually of a greenish-yellow color, sometimes red in places, and occasionally nearly black. Where roads cross the flatwoods they are easily cut up into deep, muddy ruts, in which water stands for a long time. Occasionally a high place may be encountered with sandy soil and under cultivation, but these spots form a very small proportion of the whole area of the flatwoods.

Some of the largest bodies of flatwoods are found in the anticlinal part of the Coosa Valley, below Gaylesville, in Cherokee county, extending down to Gadsden (well exposed below Cornwall, at Cedar Bluff, and below Round Mountain), and thence below Gadsden, in the direction of Springville, nearly to the latter place; also in Jones' Valley, between Elyton and Jonesboro, and in small patches farther south in Jones' and Roup's Valley.

In the immediate valley of the Coosa river the shales have usually a superficial covering of sand and pebbles belonging to a much more recent formation, but along the river bluffs they may be seen underneath the surface beds. Throughout these flatwoods the outcroppings of the lime-

stone are frequent, and in places there is very little soil, the rocky surface being then usually occupied by cedar glades. Similar glades are also often formed by the shaly limestones of the Trenton period.

From the flatwoods between Springville and Gadsden a specimen of soil was collected, which may be considered as a representative. The analysis is as follows:

No. 70. *Flatwoods soil* (the Lower Silurian shale) from three miles northeast of Asheville, Saint Clair county. Depth, 10 inches; vegetation, chiefly post oaks and short-leaf pine, with red, Spanish, and a few black-jack oaks. Color, gray on top, changing within three inches to buff-yellow.

FLATWOODS SOIL (LOWER SILURIAN SHALE).

	No. 70.	
Insoluble matter	70.650	79.583
Soluble silica	8.933	
Potash		0.277
Soda		0.078
Lime		0.159
Magnesia		0.478
Brown oxide of manganese		0.079
Peroxide of iron		6.528
Alumina		7.497
Phosphoric acid		0.075
Sulphuric acid		0.013
Water and organic matter		4.777
Total		99.544
Hygroscopic moisture absorbed at		11.15 27.2 C.°

The analysis shows that this is not such an inferior soil as its total neglect by the farmers would indicate, although the phosphates and vegetable matter are low. The natural growth, also, which is of fine, sturdy trees, tells in its favor. Many soils are successfully tilled which have no better chemical composition than this. Physically, however, it is too heavy and cold for cultivation, except where mixed with sand, as is the case near the banks of some of the streams which traverse it. Almost the only inhabitants of the flatwoods are to be found along these water-courses. During the winter and spring the roads are almost impassable by reason of mud and holes.

In its uppermost portions this formation exhibits very similar strata to the lowest beds of the next succeeding, there being no well-defined line of demarkation between them.

The great body of deep, red-colored, clayey loams occurring in the Coosa Valley region, and especially in its eastern part, may be assigned, as to their origin, either to the lowermost of the beds of the Shale or to the uppermost of the Dolomite. They will be more particularly described under the next head, though in part, without doubt, belonging here.

The Magnesian Limestone or Dolomite.—This in Alabama has the widest distribution of any of the calcareous formations, and for this reason, and because it underlies a large proportion of the cultivated valleys in this part of the State, its importance from an agricultural standpoint is very great. It has been stated that the lower beds of the Dolomite are more calcareous, the upper, as a rule, siliceous or cherty, and the resulting soils in their extremes are of two kinds:

1. A clayey loam of light-yellowish to orange-red colors and of varying thickness, the average being perhaps one and a half feet. The subsoil is usually heavier, being a rather stiff clay or clay loam of a red or yellow color. Both soil and subsoil are often filled with lumps of limonite or brown iron ore. Beneath the subsoil, at varying depths, lies the Dolomite or limestone. There is a great variety in the color of the top soil between a very light-yellow, almost gray, and a deep red and brown, but the subsoil is commonly a yellow or red clay, and it is not unusual to find these soils and subsoils, especially those of lighter colors, filled with angular fragments of chert.

The characteristic timber upon the red lands is red, Spanish, post, and black-jack oaks, hickory, short-leaf pine, and dogwood; in low grounds, sweet gum and sour gum in addition to the above.

Some of the best farming lands in the State are based upon these lower beds of the Dolomite and upon the immediately underlying calcareous parts of the Shale, and their widest distribution is to be seen in the eastern part of the Coosa Valley, in Cherokee, Calhoun, and Talladega counties,

and southward, in the same direction, in Shelby and Bibb counties. The greater part of the red and brown loams, with deep red-colored subsoils occurring along the eastern border of this long series of valleys is derived from the Dolomite, but red and brown loams of a somewhat similar nature are also derived both from the Shale below and from the Trenton rocks above the Dolomite. In the anticlinal valleys these lower beds of the Dolomite do not form the surface to so great an extent, and the deep red soils are of less frequent occurrence than in the Coosa Valley.

2. The upper siliceous beds of the Dolomite, in disintegrating, yield as a rule gray soils, which are filled with angular chert fragments. The subsoils are mostly of a yellowish to red color and of clayey substance, though the clayey substratum may sometimes lie at considerable depths below the surface. The agricultural characters of the lands made by these upper beds vary between wide limits, from good brown loams on the one hand to gray siliceous and nearly barren soils on the other.

The cherty portions of the Dolomite, from the weathering away of the calcareous part, gradually accumulate and protect the strata from further erosion, and in this way the chert ridges so characteristic of the formation originate. The chert, which is of concretionary nature (and not bedded) occurs sometimes in masses of great size, and the surface of the hills is so covered as to leave very little soil exposed, and that of a highly siliceous character. In such cases the growth is chiefly of long-leaf pine and black-jack oak. The broad chert ridges of the Coosa Valley in Cherokee, Calhoun, Talladega, and Shelby counties are very commonly timbered with the long-leaf pine.

Occasionally the country formed by this part of the Dolomite is rolling or slightly broken, rather than hilly, varied with lime sinks and outcrops of the cherty Dolomite. The southwestern part of Talladega county, near the Coosa river, furnishes a good example of these rolling piny woods, which in many respects remind one of the rolling piny woods of the southern counties. Such soils have little to recommend them, and we find the country almost uninhabited, except along the banks of the streams which drain it, and these

are few in number. Where the chert is less prominent as a surface material the gray lands are frequently of very fair quality, and, while not so fertile as some of the red lands, are thought to be better adapted to the cotton crop, especially where commercial fertilizers are used.

The better grades of the gray, gravelly lands are timbered with oaks and short-leaf pine, hickory, dogwood, etc., while those of a sandier nature have the long-leaf pine, associated with post, Spanish, and black-jack oaks and small hickories. The gray pine lands near the Alabama Furnace, in Talladega county, may be taken as types of this last named variety.

In the outlying valleys there is always at least one of these chert ridges occupying the center of the valley, but it is more commonly separated into two by a narrow valley resting on the more calcareous lower parts of the Dolomite, or by a belt of flatwoods derived from the underlying shales. These ridges are timbered usually with post, black-jack, and Spanish oaks, with some chestnut and short-leaf pine. The long-leaf pine is also found where the siliceous matter preponderates. Occasionally the cherty matter assumes the form of a sandstone or conglomerate, which forms considerable hills. This is best seen in the Salem hills, near Jonesboro', in Jones' Valley, and again a few miles southwest of Springville, in Saint Clair county. The Salem hills have a characteristic growth of long-leaf pine, as yet untouched by the woodman's ax.

The chemical composition of typical soils derived from the rock varieties occurring in the Dolomite are fairly exhibited in the analyses of four red-loam soils and one gray, cherty soil taken from several localities. Only the better soils, such as are under cultivation, have been examined. The barren soils of the chert hills and pine woods are not often in cultivation, and have not, therefore, been selected for analyses. In Calhoun, Talladega, Shelby, and Bibb counties the red soils appear most prominently.

No. 71. *Red valley soil* from 1½ miles south of Jacksonville, Calhoun county. Depth, twelve inches; vegetation, red, Spanish, and post oaks, hickory, dogwood, and short-leaf pine; color, dark-red. This kind of soil occurs over a good

proportion of the valley below Jacksonville and around Alexandria.

No. 76. *Red valley soil* from near Mrs. Walker Reynolds' place, Talladega county. Depth, twelve inches; vegetation, red, Spanish, white, and post oaks, sweet and sour gums, and hickory; color, dark-red. This is a fair sample of the red soils which make the valley of Talladega one of the most beautiful parts of the State. The same soils are seen further south, in Shelby and Bibb counties, those around Montevallo being of this nature.

No. 45½. *Red upland soil* (Dolomite) from near Pratt's ferry, Bibb county. Depth, twelve inches; vegetation, white, black, post, and other oaks, chestnut, hickory, walnut, mulberry, dogwood, with occasional black gum and cedar; color of soil, brown; of subsoil, reddish-brown.

No. 67. *Little Cahaba Valley soil* (Dolomite) from six miles southwest of Springville, Saint Clair county. Depth, 12 inches; vegetation, red, black, and Spanish oaks, hickory, chestnut, sweet gum, and persimmon; color, reddish-brown.

No. 69. *Gray upland soil* (Dolomite), one mile north of Ashville, Saint Clair county. Depth, ten inches; vegetation, red and Spanish oaks, poplar *(Liriodendron)*, dogwood, and short-leaf pine, with some sweet gum and persimmon; color, brownish-gray. Both soil and subsoil are commonly filled with angular fragments of chert.

Magnesian Limestone Soils (Lower Silurian).

	Calhoun County.	Talladega Co.	Bibb County.	Saint Clair County.	
	Red valley soil.	Red valley soil.	Red upland soil.	Little Cahaba Valley soil.	Gray upland soil.
	No. 71.	No. 76.	No. 45½.	No. 67.	No. 69.
Insoluble matter	80.520	64.070	81.480	73.433	83.440
Soluable silica	3.941 } 84.461	7.647 } 71.717	6.530 } 88.010	7.459 } 80.892	4.230 } 87.670
Potash	0.290	0.339	0.328	0.240	0.109
Soda	0.062	0.111	0.027	0.041	0.018
Lime	0.112	0.091	0.255	0.225	0.202
Magnesia	0.260	0.143	0.210	0.476	0.181
Brown oxide of manganese	0.057	0.137	0.189	0.241	0.042
Peroxide of iron	5.011	7.157	2.016	5.518	2.178
Alumina	5.722	11.229	5.614	7.498	4.521
Phosphoric acid	0.126	0.176	0.110	0.165	0.093
Sulphuric acid	0.056	0.010	0.167	0.097	0.048
Water and organic matter	4.501	8.298	3.587	4.719	0.301
Total	100.658	99.408	100.513	100.022	100.363
Humus	.....	0.984	.....	.....	.....
Available phosphoric acid	.....	0.020	.....	.....	.....
Hygroscopic moisture	8.063	19.400	4.528	9.525	8.528
absorbed at	26.7 C.[a]	24.4 C.[a]	28.3 C.[a]	9.2 C.[a]	26.7 C.[a]

In comparing these soils with each other it is seen that they are all tolerably good soils, having an adequate supply of available potash (except in the case of No. 69), phosphoric acid, and also of lime and magnesia. In these respects the red soils, as a class, are superior, but the gray soil has on its side the advantage of being more easily tilled, as it is thrifty because of alarge percentage of lime, and is generally considered a safer soil. No. 76 is rather deficient in lime, and also in available phosphoric acid. In retentiveness of moisture the upland soil (No. 45½) is a little deficient, and in its composition also, it approaches closely to the gray soil.

The soils which most resemble the above are those of the Tennessee Valley, in which there are the two varieties of red and grey, bearing to each other about the same relations as are seen in the above analyses. The Tennessee Valley soils are, if anything, slightly better than those of the region we are discussing.

In the county descriptions will be found fuller discussions of the qualities of these soil varieties from the farmers' standpoint.

Chazy and Trenton.—The lowermost of the Trenton rocks are impure argillaceous limestones and purer blue limestones, the upper calcareous shales. As a rule, the limestone predominates, and the prevailing soils are, therefore, good strong loams, somewhat calcareous and resembling the soils of the lower part of the Dolomite, or those of the Saint Louis group of the Sub-Carboniferous. The formation as a whole is valley-making, but the lower beds, which are often aluminous, frequently form low, rounded hills, along the sides of which the strata outcrop in long step-like ledges. In such cases they are usually covered with a growth of cedars.

In the subordinated valleys in the eastern part of the Coosa Valley, the Trenton rocks are usually associated with those of the Dolomite, the latter commonly forming the northwestern and the former the southeastern side of the valley range; but the Dolomite, as a rule, far exceeds the Trenton in superficial extent. In the anticlinal valleys the Trenton rocks are found as a narrow belt on each side of

the central area of Dolomite and Shale. In many instances they may be found high along the sides of the ridges of the Clinton or Red Mountain group, even occurring nearly up to the summits of some of them. The outcropping ledges of limestone are then usually covered with a dense growth of cedars, and the name of Cedar mountains, commonly given to them, is not inappropriate. In the valleys, also, there are frequent patches of the rocks nearly bare of soil and forming cedar glades. The shaly upper division of this group is of secondary importance.

In Jones' and the other anticlinal valleys the purer limestones of this age are commonly seen outcropping here and there in the lower places in smooth, rounded masses of a bluish color, rising very slightly above the general surface. Very little of the original growth is now standing in those parts of the valleys which have usually been long under cultivation. The soils are brownish sandy loams with yellowish subsoils. The slightly elevated knolls that vary the uniformity in these valleys have sandy soils, and are usually covered with short-leaf pine thickets of secondary growth. There are, also, spots of low, wet, boggy soil, not at all, however, like the flatwoods before described. The following analysis will show the composition of some soils of this kind:

No. 123. *Sandy Brown-loam Soil* (Trenton) from three miles west of Birmingham, Jefferson county. Depth, 10 inches; vegetation, red and willow oaks, sassafras, and grape-vines—little of the original growth to be seen; color, brown at top, passing into yellow at 3 inches depth.

SANDY BROWN-LOAM SOIL (TRENTON LIMESTONE), JEFFERSON COUNTY.

	No. 123.	
Insoluble matter	85 990	90.331
Soluble silica	4.341	
Potash		0.176
Soda		0.028
Lime		0.152
Magnesia		0.116
Brown oxide of manganese		0.041
Peroxide of iron		2.840
Alumina		3.188
Phosphoric acid		0.066
Sulphuric acid		0 051
Water and organic matter		2.522
Total		99.511
Hygroscopic moisture		7.835
absorbed at	24.4 C.°	

This is a soil of only average fertility, and probably of little durability, but thrifty and easily tilled.

Clinton.—The rocks of this formation, calcareous sandstones and shales, with beds of red iron ore, yield sandy soils of considerable fertility, but their location on the steep hillsides makes them of little importance in agriculture. The red-ore ridges are, in reality, made up of three formations: the Clinton, the Black Shale, and the siliceous division of the Sub-Carboniferous. The usual position of these ridges is on each side of the anticlinal valleys of the State, skirting the escarpments of Coal Measures, which form the borders of these valleys. In some places the ridges are duplicated on one side of the valley; but they are never wanting in the positions above indicated (except where ingulfed by a fault), though sometimes quite insignificant in height on one side.

In the western or anticlinal portion of the Coosa Valley a red-ore ridge runs parallel with the eastern edge of Lookout Mountain, and a similar ridge skirts the western edge of the Coosa Coal-fields, in the normal positions above mentioned; but in the eastern or faulted portion of the valley the red ridges are not associated with the Coal Measures, but form parts of synclinal basins holding the rocks of the Sub-Carboniferous formations. The four localities thus far

known of red-ore ridges in the eastern part of the valley are in the Dirtseller and the Gaylor mountains, in Cherokee county, in the mountain near Columbiana, in Shelby, and in the vicinity of Pratt's Ferry, in Bibb county. The mountain near Columbiana has along its base a conglomerate which probably underlies the Red Mountain rocks proper and belongs to the Medina group. Where the red ridges are not too steep for cultivation their soils are well adapted to most of the southern crops, especially grain. The analysis which follows shows the average red mountain soil.

No. 68. *Red Mountain Soil* (Clinton), from three miles north of Springville, Saint Ciair county. Depth, 10 inches; vegetation, large poplars, white oaks, and chestnuts, with hickory, black gum, and red oak; color, chocolate-brown, when cultivated.

RED MOUNTAIN (CLINTON) SOIL, SAINT CLAIR COUNTY.

	No. 68.	
Insoluble matter	81.560	85.240
Soluble silica	3.680	
Potash		0.206
Soda		0.037
Lime		0.363
Magnesia		0.279
Brown oxide of manganese		0.214
Peroxide of iron		4.918
Alumina		3.539
Phosphoric acid		0.168
Sulphuric acid		0.083
Water and organic matter		4.830
Total		99.877
Hygroscopic moisture		9.799
absorbed at		27.2 C.°

For the amount of insoluble matter this soil has a fair percentage of potash, a large percentage of phosphoric acid and lime, and is rather above the average in fertility, as might be inferred from the luxuriance of the forest growth which it supports. The Red Mountain soils are admirably suited to the production of small grain, but not for cotton, which is inclined to run to weed, at the expense of the fruit, unless restrained by super-phosphates or other similar manures.

The above remarks apply to the red or brown soils only of these ridges, for it must be remembered that they have gray, flinty, gravelly soils usually on one side and the red soils on the other.

The Black Shale, which follows next after the Clinton, rarely, if ever, takes part in the formation of cultivated soils. It is, at best, only a few feet thick, and as it nearly always occurs in steep ridges it is of comparativey little importance agriculturally.

Sub-Carboniferous.—In the Coosa and outlying valleys of middle Alabama this formation, though occurring only in narrow belts, is of great importance, since it forms the basis of some of the most desirable farming lands in the region of its occurrence.

The surface distribution of the Sub-Carboniferous strata is practically the same as that of the red-ore ridges, for, besides forming a part of the ridges themselves, they occupy the depressions between these ridges and the escarpment of the Coal Measures, and in the Coosa Valley they form the surface in the four small synclinal basins mentioned in a preceding section. This formation, as a whole, has two well-marked divisions—the Mountain Limestone and the Siliceous. The former, as its name implies, occurs along the sides of the mountains of the Coal Measures, and presents no tracts of arable land in this part of the State.

The lower group, which is generally known as the Siliceous, is itself subdivided, and its two parts are very unequally concerned in the formation of tillable lands, for the lowermost or more siliceous division is, as we have seen, usually associated with the Clinton rocks in the formation of the red-ore ridges, which, because of their steep slopes, are not much in cultivation. The upper and more calcareous division of the Siliceous group is the true soil-former of these belts. These soils are yellowish, reddish, and brown loams, similar to the soils of the red lands of northern Alabama, which are based upon the same rocks.

The principal discussion of this class of soils will be under the next division in northern Alabama, but the following analysis of a soil from Dry Valley, in Cherokee county (basin of the Dirtseller), may serve to represent the compo-

sition of the soils of the narrow valleys of middle Alabama:

No. 111. *Red Lands Soil* (Sub-Carboniferous), Dry Valley, Cherokee county, one mile northeast of Gaylesville. Depth, 8 inches; vegetation, red, post, white, and Spanish oaks, hickory, persimmon, chestnut, black gum, sourwood, dogwood, and a second growth of short-leaf pine; color, reddish-brown.

RED LAND SOIL, CHEROKEE COUNTY.

	No. 103.	
Insoluble residue	78.725	84.767
Soluble silica	6.042	
Potash		0.261
Soda		0.124
Lime		0.330
Magnesia		0.395
Brown oxide of manganese		0.215
Peroxide of iron		3.707
Alumina		5.077
Phosphoric acid		0.089
Sulphuric acid		0.097
Water and organic matter		5.150
Total		100.212
Humus		1.365
Available inorganic		1.061
Available phosphoric acid		0.029
Hygroscopic moisture		4.500
absorbed at	26.7 C.°	

This soil is somewhat deficient in its retentiveness of moisture, as also in phosphoric acid; otherwise it is a very good soil. The high percentage of lime makes available its whole content of plant-food. The percentage of humus in this soil is also quite high, as well as the proportion of phosphoric acid immediately available.

A fuller exhibition of the characters and variations of these Sub-Carboniferous brown loams will be seen under the heading of "The Tennessee Valley Region," (page 217), where they are widely distributed, and are of great importance argiculturally.

The Coosa and Cahaba Coal-fields, although occurring in this division, are best described, together with the Coal Measures of the Warrior Field, under the next division.

NORTHERN DIVISION.

This division, as already stated, adjoins the first or middle division on the northwest, and embraces most of the State lying north and west of a line drawn from Chattanooga, Tennessee, through Birmingham, nearly to Tuscaloosa. The area thus included is estimated at 9,700 square miles, and embraces the following counties and parts of counties: All of Lawrence, Winston, Walker, Cullman, Morgan, Limestone, and Madison, parts of DeKalb, Cherokee, Etowah, Jackson, Marshall, Blount, Jefferson, Tuscaloosa, Fayette, Marion, Franklin, Colbert, and Lauderdale.

SUBDIVISIONS.—The two parts into which this division is, by its topographical and agricultural characters, naturally subdivided, are: 1. The continuation and terminus of the great Cumberland Table-land, which, in Alabama, includes the Sand mountain and its outliers, Lookout and Blount Mountains, on the south, and the detached spurs lying beyond the Tennessee on the north and the Warrior Basin, into which the table-lands of Sand Mountain gradually sink beyond the southwestern line of Blount county. 2. The great Valley of the Tennessee.

The rock masses, which in this division are concerned in the structure of the country and in the production of the soils, are referred to two formations, the Sub-Carboniferous and the Coal Measures. In some parts of this area the Stratified Drift overspreads the country rocks and forms the soils, but the drift belt, together with its outreaching marginal parts, which overlap other formations, will be treated as a whole under another head. The approximate horizontality of the strata, and the circumstance that the soils, almost without exception, have been derived from the immediately underlying rocks, have already been commented upon, and the close connection of the agricultural with the geological features has been pointed out. The two component parts of this division are most conveniently described separately.

COAL-MEASURES REGION.

COOSA AND CAHABA COAL-FIELDS.

The Coosa field embraces about 30 square miles in the northwestern part of Calhoun, about 150 square miles in Saint Clair, and about 235 square miles in Shelby county, making an aggregate of 415 square miles.

The Cahaba field includes about 50 square miles in Saint Clair, 100 in Jefferson, 160 in Shelby, and 125 in Bibb county, aggregating 435 square miles. Only 75 square miles in Bibb county are free from Drift, so that the area depending upon the Coal Measures for its soil is reduced to 385 square miles.

In both these fields the strata, consisting of sandstones, conglomerates, shales, and coal beds, are tilted at considerable angles, and, possessing varying degrees of resistance of disintegration and erosion, have been very unequally degraded? The main ridges and valleys have the general direction of northeast and southwest, corresponding to the outcrops of the tilted strata; but this uniformity is often greatly obscured and in places obliterated by the irregularities produced by the streams which traverse the fields across the outcrops. In the presence of these inequalities, produced by the folding or the tilting of the strata, these fields differ from the great Warrior field, where the topographical features have no such direct connection with the geological structure. All the coal-fields have most of their characters in common; hence a further description of the topography, as well as of the agricultural features, can be well deferred till we come to speak of the Warrior field. It seems to be well established that the three coal-fields of Alabama were once continuous, and that they have been separated by folds (since denuded) and by faults.

THE WARRIOR FIELD.

That part of the Coal Measures of Alabama which is drained by both forks of the Warrior river and their tribu-

taries has received the name of the Warrior Coal-field. This field may be divided into two parts, the Plateau or Table-land, and the Warrior Basin proper.

The Table-Land.—It is characteristic of the table-lands or plateaus that the limestone beds, which underlie the capping of Coal Measures rocks, are above the general drainage level of the country. This arrangement of the two classes of strata determines in great measure the character of the scenery, for the removal by erosion of the more perishable limestones causes the undermining of the harder sandstones above, which from time to time break off with vertical faces, forming cliffs. In height the plateaus diminish continuously toward the southwest, passing gradually into the Warrior basin; in the State of Tennessee, their elevation above the surrounding country varies from 850 to 1,000 feet. In Jackson and Madison counties some of the spurs attain an equal height, but further southwest, in Morgan and Marshall, the elevation will not average more than 550, and in Cullman and Blount counties not more than 360 feet, and near the Mississippi line they come down to the drainage level. The main body of the table-land is known as Sand Mountain, lying between the Sequatchie fold, or Brown's and Tennessee Valleys, on the northwest, and Will's and Murphree's valleys on the southeast, and including parts of DeKalb, Jackson, Marshall, and Blount counties. The highest parts of this table-land are to be found along its edges, overlooking the valleys above mentioned, and there is a general slope both ways toward the center of the plateau, which thus becomes a shallow, elevated trough.

Beyond Wills' Valley is Lookout Mountain, an outlier of Sand Mountain, and beyond Murphree's Valley (southeast) Blount Mountain, a spur of the main table-land. All these parts have similar structure, and their elevated rims, adjoining the valleys, are usually only slightly indented by the water-courses, except where some large stream leaves the plateau, as in the cases of Little river, on Lookout, and Short creek, on Sand Mountain. Northwest of the Tennessee river, however, the tributaries of that stream have cut the elevated lands belonging to this division into a number of more or less isolated peaks, some of which, especially in

the northeastern part of the State, have still the capping of Coal Measures, which have been entirely removed from many of those lying farthest toward the west. Overlooking the Tennessee Valley, in Lawrence and Franklin counties, the elevated rim, which is locally called Sand Monntain, is the border of the Warrior Basin, and will be considered along with it.

Approximately, the area of the elevated lands or plateaus as above limited would be about 1,690 square miles on Sand Mountain and its spur in Jackson, DeKalb, Marshall, Etowah, Morgan, Saint Clair, and Blount counties, about 290 square miles on Lookout Mountain, in DeKalb, Cherokee, and Etowah, about 580 square miles in the detached spurs of the Cumberland northwest of the Tennessee, in Jackson, Madison, and Marshall, and to these might be added about half the area of Cullman county, whose measures partake of the characters of both the table-lands and of the basin, about 295 square miles; aggregating, in all, 2,855 square miles. A not inconsiderable part of this area north of the Tennessee is mountain slope, and it is not strictly table-land.

The Warrior Basin.—This, like the table-land, is in general a trough, shallow and sloping from northeast to southwest, with slightly elevated rims next to the Tennessee Valley on the north, and Jones' Valley on the south. As Brown's Valley divides the plateau, so its continuation southwestward as a ridge divides the basin into two unequal parts. Southwest of the confluence of the two Warriors these two parts seem to come together in one common basin by the sinking away of the ridge which separates them higher up.

The Warrior Basin includes all of Walker and Winston and parts of Cullman, Morgan, Lawrence, Franklin, Marion, Lamar, Fayette, Tuscaloosa, and Jefferson counties, and will aggregate about 4,955 square miles. The whole area of the Warrior field is thus estimated at about 7,810 square miles. *(a).* The surface of the elevated border lands here

a. Of the 4,955 square miles underlaid by the Coal Measures of the Warrior field, 1,990 are covered with Drift deposits, so that only 2,965 of the whole area have soils which are derived from the sandstones, etc., of the Coal Measures. The proportion may be even smaller than this estimate makes it.

included is comparatively level, though sufficiently undulating, and in places the streams have cut deep gorges into the hard sandstones and conglomerates. In the basin there is much more inequality of surface, and in the vicinity of streams the country is often extremely rough, although the water-sheds are seldom more than 250 or 300 feet above the general level of the streams. Along the edges of both table-land and basin the higher rims are parts of folds of the strata, and they are of sufficient height to determine the direction of the water-courses, and hence the nature of the topography. In the basin there are numerous undulations of the strata, but they are rarely of sufficient importance to affect the topography.

AGRICULTURAL FEATURES.—The Coal Measures present substantially the same characters everywhere as regards soils, but important variations result from differences in latitude and in elevation above the sea. The plateaus seem to be specially suited to the growth of fruits and vegetables and nutritious grasses; but since cotton is the southern crop *par excellence*, neither the plateaus nor the other parts of the coal-fields have hitherto been in good repute as farming lands. As yet, this part of the State is comparatively thinly settled, but its many advantages are gradually being appreciated.

In the discussion of the soil varieties of the Warrior Field, reference is also made to those of the other coal-fields, as they are entirely similar. Since the soils of this region are derived from the disintegration of the country rocks, and as these are sandstones, shales, and conglomerates, the agricultural character of the coal-fields is easily understood. All the soils are sandy and more or less deficient in vegetable matter and lime. The subsoils vary from yellowish or reddish clay to sand. The better classes of these soils are light-colored loams, with yellowish or reddish subsoils, and these are capable of improvement, since they well retain all fertilizers. The gray soils with light-colored to whitish subsoils, deficient in clayey matter, are too porous and drouthy to be profitably cultivated, and

they do not retain the fertilizers that may be applied to them.

In the order of their relative importance, both as to surface distribution and agricultural value, the cultivated soils of this region may be classed as follows:

1. *Sandy loams* of gray, yellowish to brown colors, forming perhaps three-fourths of the area. These soils vary between tolerably wide limits, and the natural growth is usually a mixture of various upland oaks, with some hickory and short-leaf pine. The analysis given (No. 110) may be taken as representing the average composition of soils of this class.

2. *Creek-bottom Soils.*—These are, according to locality, sandy or loamy, and are generally in cultivation when the proportion of sand is not too great. The bottoms are usually narrow, especially when the surrounding country rocks are hard sandstones or conglomerates. The growth is of oaks, poplar *(Liriodendron)*, beech, holly, and occasionally what is known as spruce pine. The more loamy bottom soils are underlaid with a reddish clay (hard), not mixing readily with the surface soil. The sandier varieties have a substratum of sand, and are not altogether so fertile as the preceding; both, however, produce well, are easy of tillage, and are generally under cultivation.

3. *Sandy Soils.*—The most highly siliceous sandstones and conglomerates yield, on disintegration, a very sandy soil, which supports a growth of stunted black-jack oaks and short-leaf pines. Such soils are scarcely at all cultivated, and are of little importance agriculturally.

No. 110. *Upland soils*, Sand Mountain, near Valley Head, DeKalb county. Depth, 20 inches; vegetation, chiefly red (Spanish) oak, some black oak, short-leaf pine, hickory, dogwood, and chestnut; color, light-gray as far as taken.

SAND MOUNTAIN SOIL (COAL MEASURES), DE KALB COUNTY.

	No. 110.	
Insoluble matter	86.350	90.702
Soluble silica	4.352	
Potash		0.230
Soda		0.141
Lime		0.068
Magnesia		0.154
Brown oxide of manganese		0.070
Peroxide of iron		1.443
Alumina		6.324
Phosphoric acid		0.073
Sulphuric acid		0.062
Water and organic matter		0.844
Total		100.111
Hygroscopic moisture		3.368
absorbed at		16. C.°

The yield of fresh land at its best, without manures, is estimated at half a bale of cotton to the acre.

From the above analysis it will be seen that the soil contains a large proportion of sand and other siliceous matter (90.7 per cent.), and that there is a notable deficiency of lime and phosphoric acid, with a fair quantity of potash. The soils, therefore, of which this is a representative, may be looked upon as rather below the average in fertility; but having usually a good basis of clayey matter they are susceptible of improvement. The agricultural history of this class of soils accords well with the teachings of the analysis, for until quite recently these lands have been almost totally neglected, being deemed comparatively worthless. Recently, however, the use of artificial fertilizers has become general, and it has been found that with a small outlay for phosphates or guano the best results are obtained. These soils are now generally considered the most reliable for cotton, though never cultivated without manures.

The Tennessee Valley Region.

Under this head are included not only the immediate valley of the Tennessee river, but also the whole region in Alabama drained by its tributaries, except the anticlinal valley, down which the river flows in Jackson county, and

the table-lands of DeKalb, the Cumberland spurs in Jackson, Madison, and Marshall, already described, and the Drift-belt in Franklin, Colbert, and Lauderdale counties. With these limits, therefore, this region will embrace an area on both sides of the Tennessee extending from the State line on the north to the Coal Measures of the Warrior field on the south. The average width of this drainage area from north to south is about 45 miles, and includes parts of Jackson, Marshall, Morgan, Lawrence, Franklin, Colbert, and Lauderdale, and all of Limestone, and part of Madison counties, aggregating 4,530 square miles. (*a*).

The extreme western parts of Lauderdale, Colbert and Franklin counties, while falling within the above limits, are best described in another connection, since the soils are derived from the surface beds of drift which there overlie the country rocks.

GENERAL TOPOGRAPHICAL FEATURES AND SUBDIVISIONS.—The general features of this region are those of a plain 12 to 15 miles wide, the Tennessee Valley proper, through which the river flows in its tortuous path, the valley being bounded both on the north and on the south by hilly, and in some places almost mountainous, country, and the hills and the valley belonging to the same geological age, the configuration of the whole area being the result of erosion during long geological periods by waters whose present representatives are the Tennessee and its tributaries.

The average elevation of the summits, which represent approximately the general level of the original land surface, is in the eastern part of this region about 2,000 feet above the sea, and there is a gradual slope westward, so that the summits near the Mississippi line are not more than from 900 to 1,000 feet above sea-level. The general surface of the lowlands exhibits a similar slope, the elevation at Huntsville being 612 feet, at Courtland 560 feet, and at Dickson 488 feet. The hilly country in the northern part of this

a This represents approximately the whole area in northern Alabama underlaid by sub-Carboniferous strata. Of this, however, some 650 square miles in the western part of the valley are covered with drift, and hence are classed with the short-leaf pine uplands. This leaves 3,880 square miles, in which the soils are based on the sub-Carboniferous rocks.

area is known as Barrens, and is a part of the great highland rim of Tennessee. These have generally light colored siliceous soils, and are not much under cultivation, but they include many tracts with fertile calcareous soils.

South of the Barrens lies the Valley proper of the Tennessee, which has usually a fertile calcareous soil of a deep red color. The surface is almost level, the uniformity broken here and there by slight elevations, generally covered with trees and made up of fragments of chert. Upon these wooded knolls are frequently situated the dwelling houses of the planters. Throughout the whole area sink-holes and caves are common and almost characteristic.

The southern border of the valley is made by the escarpment of the Warrior Coal-field—Sand Mountain, as it is usually called—rising above the valley to a height which will average, perhaps, 600 or 700 feet. Along the northern face of this escarpment, about half way, is a terrace, or bench, which in the eastern part of Morgan county is very narrow, but widens going westward, and a considerable depression is formed between it and Sand Mountain. In Lawrence and Franklin counties this depression is deepened iuto a valley with calcareous soils (Moulton and Russell's Valleys), and the bench, now completely separated from Sand Mountain, forms a very conspicuous feature of the landscape, known as the Little Mountain range. These valleys have the same general characters as the Tennessee Valley, and are partly based on the same rocks. The Little Mountain range terminates toward the north with rather bold escarpments, but slopes more gently southward.

The three divisions of the Tennessee drainage area in northern Alabama are the Barrens, the Valley lands, and the Little Mountain range, and they divide the surface about as follows: Barrens, 910 square miles; valley lands, 2,430 square miles; and Little Mountain range, 540 square miles.

Geological Structure.—Leaving out of consideration the mountain spurs of the Cumberland range in Jackson and Madison, the anticlinal fold of the Sequatchie in Jackson, and Drift in Lauderdale, Colbert, and Franklin, the surface rocks to which the soils of the Tennessee Valley owe their

origin belong to a single formation, the Sub-Carboniferous, the subdivisions of which, as adopted by the State geological survey, are as follows: Upper: Calcareous—Mountain Limestone, or Chester; lower: Siliceous—Saint Louis limestone and Keokuk.

In addition to the above, the strata of the Devonian and the Upper Silurian formations are exposed along certain creeks in the northern part of this region, but their superficial extent is small, and their part in the formation of the soils insignificant.

The following illustration, taken from the geological report of 1877–78, and representing a section through the strata from the State line on the north, through Courtland and Moulton, to the Sand Mountain on the south, will best illustrate the description below, and will make clear many of the circumstances affecting the distribution of the various agricultural features of the Tennessee Valley:

Fig. 3.—SECTION ACROSS THE VALLEY OF THE TENNESSEE IN NORTHERN ALABAMA.

EXPLANATIONS.—I. Silurian. II. Black Shale. III. Lower Siliceous. IV. Upper Siliceous. V. Mountain Limestone. VI. Coal Measures. *a.* Sand Mountain. *b.* Moulton. *c.* Big Nance Creek. *d.* Little Mountain. *e.* Courtland. *f.* Tennessee River. *g.* "Barrens." *Scale.*—Horizontal, 1 inch, 6 miles; vertical, 1 inch—1000 feet.

LITHOLOGICAL CHARACTERS, DISTRIBUTION, ETC.—1 *and* 2, *Silurian and Devonian.*—These two formations, which are composed of limestones and shales, are exposed only in the bluffs of streams which drain the northern part of this area, and which have their sources within the Tennessee line. The slight dip of the strata brings these beds within the reach of the denuding waters in the north, while farther south they pass below the overlying beds, as may be seen in the illustration. As stated, they are of no consequence from an agricultural standpoint, because of their very limited occurrence in Alabama, except along the borders of Elk river, in Limestone county, where they form some bodies of very good land.

3. *Lower Siliceous.*—These beds are supposed to be equivalent to the Keokuk and Burlington beds of other States and to the Barrens group of Tennessee. The most important rocks of the formation are highly siliceous limestone, alternating with a pure cystalline limestone, admirably suited to architectural purposes, and impure shaly limestones. The resistance to erosion offered by the flinty material with which a large proportion of the limestones are impregnated gives rise to the broken, rugged surface which characterizes so much of the Barrens. The whole thickness of the formation is about 300 feet, in which, 100 feet below, are the purer limestones, and 200 feet above are the more siliceous beds. The distribution of these beds as surface rocks is coextensive with that of the Barrens, as shown on the map.

4. *Upper Siliceous.*—This is the equivalent of the Saint Louis or Coral Limestone group, and is in many respects the most important of the formations occurring in northern Alabama, for from it are derived most of those soils which have made the Valley of the Tennessee one of the best farming areas of the State. The rocks are, as a whole, cherty limestones, usually highly fossiliferous, and sometimes argillaceous. The chert of this division is generally easily recognized, being found in nodular masses filled with impressions of fossils. The country where this formation appears as surface rock is generally level, with low knobs, formed of fragments of chert, remnants of the cherty por-

tions of the limestone. These chert masses are sometimes much decomposed, weathering occasionally to a white chalky-looking siliceous powder.

The soil over the Saint Louis limestone is usually colored deep red and orange by the hydrated oxide of iron with which it is impregnated, and this material is occasionally found in such quantity as to form regular ore banks (limonite). The limestones of this formation appear to have suffered subterranean erosion to a greater extent than those of any other, except, perhaps, the Dolomite of the middle Alabama anticlinals. As a consequence, sink-holes, caves, underground streams, and big springs become almost characteristic of the Saint Louis group. The average thickness of the group in northern Alabama may be put at 150 feet, and its distribution as the surface rocks may be seen on the map, marked by the color of the red and valley lands, the greater part of which have been derived from it.

5. *Mountain Limestone.*—This uppermost or calcareous member of the Sub-Carboniferous formation, which is considered as an equivalent of the Chester group of other States, is composed of limestones and shales, with one bed of sandstone included. Its thickness in the eastern part of the valley, as for instance, near Huntsville, is between 650 and 700 feet; but westward it thins down, being in Lawrence and Franklin counties seldom more than 150 or 200 feet. The characters of the rocks change also with the locality, for near Huntsville they are mostly limestones, the sandstone stratum being quite thin. In Lawrence, Colbert, and Franklin counties the limestones thin out, while the sandstone becomes prominent, having often a thickness of 75 feet. In these western counties also the sandstone bed is often duplicated, its two parts being separated by limestones.

The calcareous beds of the Mountain Limestone, as the name implies, are mostly found among the slopes of the Cumberland spurs in Jackson and Madison and along the slopes of the escarpment of Sand Mountain in Morgan, Lawrence, and Franklin counties, and also along both the northern and southern slopes of the Little Mountain in Morgan, Lawrence, Colbert, and Franklin. In addition to

these localities, many of the valleys between the Cumberland spurs in Jackson and Madison and of the rich coves which indent the northern edge of the Sand Mountain in Morgan, Lawrence, and Franklin counties are based upon these limestones. The sandstone bed, on the other hand, is found as the surface rock of the terrace or bench which so generally occurs along the sides of the Sand Mountain and of the Cumberland spurs, capping many of the smaller spurs in Jackson and Madison; and also at the summit of the Little Mountain, which is only a remnant of this once wide terrace, now isolated from the main body by the cutting out of a valley between. Where the streams have cut through the Little Mountain they flow generally through deep gorges or cañons with perpendicular sides, the sandstones forming the top rock, with the limestones below. The sandstone, being undermined by the wearing away of the underlying calcareous beds, breaks off, leaving perpendicular cliffs.

The character of the topography and the distribution of the Mountain Limestone beds will be easily inferred from the above remarks, and it is perhaps only necessary to state that some of the valleys and gaps separating the mountain spurs in the extreme east of this region are based, in part, upon the calcareous portions of this formation, which in such cases extend out to some distance from the base of the mountain.

AGRICULTURAL CHARACTERS.—*The Barrens.*—Based upon the rocks of the Lower Siliceous group, the Barrens occur in greatest force in the northern part of the State near the Tennessee line, in the counties of Madison, Limestone and Lauderdale. In the valley, or red lands, occasional spots of barrens are exposed by the removal by denudation of the overlying rocks, and this is particularly the case in the vicinity of the Tennessee river itself, where the drainage has cut deepest. On the other hand, occasional spots of red lands may be found occupying the summits of the elevations in the Barrens, and thus while the general line of separation of the two land varieties may be laid down with some accuracy, nothing short of extended exploration would

enable one to mark out their precise limits. The whole area of the Barrens has been estimated at 910 square miles, of which 150 are in Madison, 400 in Limestone, and 360 in Lauderdale.

As a part of the highland rim of Tennessee, the Barrens may be described as a high plain, having an average elevation of perhaps 700 or 800 feet above the sea, with a general slope from the east toward the west and a special slope southward, caused by the drainage of the Tennessee river. The highest lands are, in general, near the State line on the north. Into this high land the streams have cut their channels, which, as a rule, are quite deep and narrow. Going southward, these indentations of the elevated plain become more numerous and widen out, the flat dividing lands narrow down, and near the larger streams become more or less rounded ridges, which are cut up by the smaller tributaries into a number of detached hills. These river hills, though often very steep, have good soils, and are generally in cultivation. Strips of the barren lands extend out into the valley lands along most of the larger streams, in some places coming down to the Tennessee itself. The western part of Lauderdale is perhaps the most broken of any of the barren lands in Alabama.

The two principal soil varieties of the Barrens are derived from the upper and lower rocks of the formation, respectively. The uppermost rocks are highly siliceous limestones, which form the surface over the greater part of this division and have given it its characteristic topographical and agricultural features, the lower beds, which are often pure limestones, being exposed chiefly in the larger creek valleys, and southward in the lowlands of the river. The disintegration of the siliceous rocks above named gives rise to the most widely distributed and characteristic class of Barrens soils, which are light colored, whitish to gray sandy loams, having a reddish or yellowish siliceous subsoil, which in turn rests upon a hard-pan impervious to water at a depth of three to five feet. This Barrens land, like some of the Sand Mountain land already spoken of, was formerly considered almost worthless for farming purposes, but has been coming rapidly into favor of late years. It has been

found that by the use of, say 200 pounds of guano to the acre, this land gives a fine yield of cotton. The main difficulty with cotton is in keeping a stand of the young plants in the early spring, as on account of the impervious hard-pan underlying the subsoil the land is often badly drained and the young plants are "scalded," and thus killed. A drain of less than four feet depth is generally useless. The subjoined analyses will show the general character of the Barrens soil.

No. 40. *Barrens soil* from near Cluttsville, Madison county, collected by Thomas B. Kelly. Depth, 8 inches; vegetation, post, black, red, Spanish, and black-jack oaks, scrub hickory, wild gooseberry, blackberry, winter huckleberry, and a coarse grass, good for sheep and cattle; color, yellowish-gray. This soil is easily cultivated, and, when properly drained, produces well. It was formerly timbered with chestnuts, since disappeared. After rains the soil hardens, thus preventing the growth of cotton till broken up with a plow.

No. 48. *Barrens soil* from near Huntsville, Madison county, collected by Colonel W. C. Irwin. Depth, 6 inches; vegetation, scrubby post and black oaks, a few hickories and dogwoods; no grass, but a thick undergrowth of dogwood bushes; color, light yellowish-gray; change of tint at 3½ inches, clay at 7 inches.

BARRENS SOILS (SUB-CARBONIFEROUS), MADISON COUNTY.

	CLUTTSVILLE SOIL.	HUNTSVILLE SOIL.
	No. 40.	No. 48
Insoluble matter	89.950	84.160
Soluble silica	2.292	4.560
	92.242	88.720
Potash	0.255	0.116
Soda	0.064	0.025
Lime	0.064	0.041
Magnesia	0.035	0.159
Brown oxide of manganese	0.150	0.041
Peroxide of iron	1.695	2.705
Alumina	3.292	4.597
Phosphoric acid	0.100	0.054
Sulphuric acid	0.178	0.045
Water and organic matter	2.024	3.388
Total	100.099	99.831
Hygroscopic moisture absorbed at	4.450 21 C.°	4.785 28 C.°

These analyses show a larger percentage of insoluble matter and a deficiency of lime and vegetable matter. The hardening of No. 40 is probably due to this lack of organic matter. In potash and phosphoric acid, considering the amount of insoluble matter, there is a sufficiency in the case of No. 40. Neither soil has much capacity for retaining moisture. These soils, like the soils of the Coal Measures, chemically somewhat similar, have generally a good foundation of clay, and are, therefore, capable of improvement.

Within the limits of the Barrens there is a class of soils making what are called the gravelly bottom lands. These are gravelly loams of gray to yellow or brown colors resting on somewhat heavier, yellowish-red subsoil. The river hills along the Tennessee in some localities are apparently of a somewhat similar nature.

No. 52. *Gravelly soil*, Limestone creek bottom, near Cluttsville, Madison county, collected by Thomas B. Kelly. Depth, not given; vegetation, poplar, beech, sugar-maple, sycamore, gum, walnut, red, white, and black oaks; color, light-brown; a somewhat difficult soil to till because of the gravel.

No. 56. *Gravelly or river hills soil*, one-fourth of a mile south of the Tennessee river, near Tuscumbia, Colbert county, collected by B. Pybas. Depth, 4½ inches; vegetation, red, white, and black-jack oaks, dogwood, white poplar, and small scrub-walnut; color, gray with shade of yellow; subsoil, dark ocher, reaching to 2 feet depth.

GRAVELLY BOTTOM AND RIVER-HILLS SOILS, BARRENS (SUB-CARBONIFEROUS).

	MADISON COUNTY.		COLBERT COUNTY.	
	Limestone creek bottom.		Tennessee River hills.	
	No. 52.		No. 56.	
Insoluble matter	79.005	85.028	79.320	86.080
Soluable silica	6.023		6.760	
Potash		0.270		0.309
Soda		0.161		0.067
Lime		0.182		0.398
Magnesia		0.224		0.226
Brown oxide of manganese		0.239		0.324
Peroxide of iron		2.871		2.969
Alumina		4.834		4.771
Phosphoric acid		0.209		0.153
Sulphuric acid		0.010		0.172
Water and organic matter		5.758		4.458
Total		99.786		99.927
Humus		1.974		.....
Available inorganic		0.860		.....
Available phosphoric acid		0.073		.....
Hygroscopic moisture		6.881		5.371
absorbed at	9.4 C.[a]		28.3 C.[a]	

These analyses indicate soils of a fair degree of fertility and durability, which, while they contain a large proportion of insoluble matter, are yet thrifty, by reason of a comparatively large percentage of lime and magnesia. In productiveness they stand much nearer the red lands than the Barrens, the average seed-cotton product per acre being given at from 800 to 1,200 pounds, while that of the Barrens will probably not average more than from 500 to 700 pounds. Perhaps less than 10 per cent. of the cultivated land of the immediate Valley of the Tennessee is of this kind.

To recapitulate, until quite recently the great proportion of cultivated lands of the Valley of the Tennessee were red limestone lands. Of late, however, the lighter and more siliceous soils of the Barrens have been found to be profitable soils to cultivate, especially with artificial fertilizers and these are now preferred by many, they being safer and easier of cultivation. The cotton staple from these lands is less likely to be stained or otherwise injured than that from the red lands.

The limestones which make the lower part of the formation yield a red or brown-loam soil, and is in most respects similar to that of the red lands of the valley. Of this no analyses have been made. This soil is confined to the borders of the streams which traverse the highlands, and, while of much better quality than the average soil of the Barrens, is of limited occurrence.

The Red or Valley Lands.—Under this head are included the Valley proper of the Tennessee, extending from the Barrens on the north to the Little Mountains on the south, the valley lying between the Little Mountain range and Sand Mountain, and the valleys and gaps separating the spurs of the Cumberland in the eastern part of this division, which are all closely related in their agricultural and topographical features. The area is estimated at about 2,430 square miles, of which 320 are in Jackson, 460 in Madison, 190 in Limestone, 240 in Lauderdale, 210 in Franklin, 150 in Colbert, 480 in Lawrence, 285 in Morgan, and 95 in Marshall counties. In this estimate are included also those calcareous lands derived from the limestones of the Mountain Limestone formation where they occur in the valleys and not upon the mountain slopes.

The general character of the valley lands has already been alluded to. They are nearly level or gently undulating, especially near the Tennessee river, on both sides; but in the gaps between the mountain spurs the surface is more broken. On account of the fertile nature of the soil most of these lands are cleared and under cultivation, but the monotony is agreeably relieved by the low knolls, which are covered with a luxuriant growth of oaks. These knolls are formed by the accumulation of the siliceous parts of the limestone, and, being too rocky for easy cultivation, are often chosen sites for the dwelling-houses of the planters. Where the flaggy limestones, either of the Saint Louis or of the Mountain Limestone group, lie very near the surface, with but a thin coating of soil, they are usually covered with a dense thicket or glade of red cedar. Sink-holes and big springs are numerous throughout the valley.

The Saint Louis or Coral Limestone has been described as a siliceous limestone, and in its disintegration it yields a

soil which, while varying between wide limits, is in general terms a sandy loam, resting upon what is usually called red clay, but which is a heavy loam, containing from two to eight per cent. of ferric oxide and about an equal proportion of alumina. The soil varies in color from mulatto to deep-red and nearly black, according to the proportions of the several ingredients. The following analyses of soils of this character from different localities will show well the variations in the quality, as well as the average composition of these lands:

No. 38. *Red Lands soil* from near Cluttsville, Madison county, collected by Thomas B. Kelly. Depth, 11 inches; vegetation, hickory, poplar, ash, red, black, and white oaks, chestnut, walnut, elm, cedar, black haw, dogwood, etc.; color of the soil, dark-brown; of the subsoil, yellowish-brown. In its physical properties this soil is very friable. Water sinks rapidly into it, and is retained by the subsoil.

No. 34. *Red lands soil* from one mile east of Tuscumbia, Colbert county, collected by B. Pybas. Depth, 10 inches; vegetation, black-jack, red, and post oaks, hickory, and scrub cedar; no undergrowth: color, dark-brown to nearly black. This soil after rains tends to form a crust, which, if not broken up, becomes nearly as hard as a rock.

No. 64. *Red lands soil* from Russell's Valley, near Russellville, Franklin county, collected by Dr. Daniel Sevier. Depth, 15 inches; vegetation, red, black, white, post, and black-jack oaks, cedar, dogwood, chestnut, walnut, wild cherry, and black locust; color, dark-brown, passing to a lighter reddish-brown in the subsoil.

RED SOILS, TENNESSEE VALLEY (SUB-CARBONIFEROUS).

	MADISON CO.		COLBERT CO.		FRANKLIN CO.	
	CLUTTSVILLE.		TUSCUMBIA.		RUSSELLVILLE.	
	Red lands soil.		Red lands soils		Red lands soil.	
	No. 38.		No. 34.		No. 64.	
Insoluble matter	77.950	83.293	76.023	85.018	75.360	80.597
Soluble silica	5.343		8.995		5.237	
Potash		0.243		0.276		0.154
Soda		0.058		0.133		0.110
Lime		0.648		0.267		0.250
Magnesia		0.058		0.381		0.250
Brown oxide of manganese		0.103		0.218		0.138
Peroxide of iron		2.873		5.230		5.623
Alumnia		6.198		5.691		8.163
Phosphoric acid		0.188		0.151		0.229
Sulphuric acid		0.025		0.020		0.039
Water and organic matter		6.620		1.794		4.100
Total		100.307		99.179		99.653
Humus		2.242		0.700		.....
Available inorganic		1.551		0.956		.....
Available phosphoric acid		0.109		0.020		.....
Hygroscopic moisture		9.760		8.840		6.14
absorbed at	21 C.°		7.8 C.°		26.7 C.°	

Since the immediate fertility of a soil depends upon the available phosphoric acid and other inorganic plant-food, the humus determinations should give us an insight into the capabilities of a soil with reference to the next succeeding crop.

The analyses show that all these soils are of rather more than average fertility; and while they do not contain unusually large amounts of phosphoric acid and potash, yet the large percentage of lime in each case renders the soil thrifty. In comparing No. 38 with No. 34, the latter is seen to be notably deficient in vegetable matter, to which may probably be ascribed its tendency to bake hard after rains. In the percentage of humus, also, they differ widely, as also in the amount of available phosphoric acid, which in No. 38 is 0.109, and in No. 34 only 0.020 per cent. All three soils have fair capacity for retaining moisture.

The creek-bottom lands in the Tennessee Valley are of varying degrees of fertility, but are generally productive,

since they contain the best parts of the uplands which surround them.

Upon the sides of the mountain spurs in Jackson, Madison, Marshall, and Morgan counties, and also along the base of the Little Mountain range, the calcareous parts of the Mountain Limestone yield a stiff clayey and limy soil, which supports a fine growth of forest trees, but which on account of their position on the mountain slopes, are not well suited to cultivation. But there are many places in the counties named where this soil is found in sufficiently level position to be profitably cultivated, and in many of the rich coves which penetrate the edges of the mountains these are the prevailing soils. No analyses have been made, but the crops produced show that they are in character somewhat like the red valley soils, though not so generally of red colors. The prevailing color is gray to black, and there are spots of black soil that recall in appearance the black prairie soils of the south, to be found in places on Little Mountain and other localities made by this formation.

The Little Mountains.—This well-marked feature of the Tennessee Valley has already been alluded to and its principal characters given. The Little Mountains proper extend from Morgan, through Lawrence and Colbert counties, out to the Mississippi line. In Madison and Jackson counties there are many small and detached spurs which have exactly similar structure to that of the main body, and they are to be considered in the same connection. All these spurs, and the Little Mountains themselves owe their existence to a stratum of sandstone in the Mountain Limestone or Chester group, which has protected them against the erosion that has wasted away the adjacent lands on all sides. From the approximately horizontal position of the strata the summits of these mountains are mostly rather level, though worn into slight depressions here and there. As a general thing these lands are not much under cultivation, since the soil derived from the sandstones is not rich, and scarcely pays to cultivate.

The northern face of these mountains is usually steep and abrupt and somewhat indented with fertile coves having red and brown-loam soils. The southern slope is much

more gradual. Where the sandstone has been removed the underlying calcareous rocks of the formation come to the surface and give rise to the so-called prairies, which are destitute of trees, because of the thinness of the soil and the proximity of the rock to the surface. Such places furnish, however, excellent pasturage. The prairie spots are generally found on the summit or southern slope of these mountains, but along their northern or steep face there is very often seen a level bench, or terrace, with the stiff, limy soils of this character.

On account of their elevation and pleasant climate the Little Mountains are favorite places of residence, and several towns are situated upon them, among which may be mentioned Somerville, Mountain Home, LaGrange, etc. Where streams have cut across the Little Mountain they flow through deep gorges, with almost perpendicular sides, and underneath some of the sandstone ledges often spring chalybeate and other mineral waters. The area occupied by the Little Mountains and similar elevations is estimated to be about 540 square miles, of which 50 are found in the detached spurs of Madison county, 140 in Morgan, 150 in Lawrence, 170 in Colbert, and 30 in Franklin.

The agricultural features of the mountain spurs here included are, as might be supposed, rather uniform. The sandstone, which forms the greater part of the surface, yields a sandy soil, which is closely like the prevailing soil in the Coal Measures. Its chief timber also resembles that of the coal regions, consisting of Spanish, post, and white oaks, with some short-leaf pine. Other trees are common in some places, as chestnuts and hickories.

The following analysis of a soil collected on Little Mountain, near the old town of LaGrange, in Colbert county, will serve to show the general nature of these lands:

No. 36. *Little Mountain soil* from LaGrange, near Tuscumbia, in Colbert county, collected by B. Pybas. Depth, eight inches; vegetation, chestnut, short-leaf pine, hickory, post-oak, and small sourwood; color, top soil dark-brown two inches; below that yellowish sand at two feet, and at five feet solid sandstone rock.

SANDY SOIL OF LITTLE MOUNTAIN, COLBERT COUNTY.

	No. 36.	
Insoluble matter	93 630	95.312
Soluble silica	1.682	
Potash		0.100
Soda		0.060
Lime		0.120
Magnesia		0.040
Brown oxide of manganese		0.102
Peroxide of iron		0.761
Alumina		1.532
Phosphoric acid		0.051
Sulphuric acid		0.028
Water and organic matter		2.055
Total		100.161
Hygroscopic moisture		1.56
absorbed at	25.6 C.°	

A rather poor soil, like that of the Coal Measures generally, but with a larger proportion of lime and of organic matter and less of potash.

SOUTHERN DIVISION.

All that part of the State south and west of the limits of the Middle and Northern Divisions is embraced in the Southern Division, which includes the whole or parts of Lauderdale, Colbert, Franklin, Marion, Lamar, Fayette, Tuscaloosa, Bibb, Chilton, Elmore, Tallapoosa, and Lee counties, and all of Pickens, Greene, Hale, Sumter, Choctaw, Marengo, Dallas, Perry, Autauga, Lowndes, Montgomery, Macon, Bullock, Russell, Barbour, Pike, Crenshaw, Butler, Wilcox, Monroe, Clarke, Washington, Mobile, Baldwin, Escambia, Conecuh, Covington, Geneva, Coffee, Dale, and Henry. The area of this division is approximately 32,335 square miles.

GENERAL GEOLOGICAL AND TOPOGRAPHICAL FEATURES AND SUBDIVISIONS.—The Cretaceous and Tertiary rocks which underlie this whole division are approximately horizontal in stratification, but have a slight dip toward the south and southwest. With the exception of part of the prairies presently to be described, the whole area is covered with

beds of drifted material which have been deposited upon an eroded surface of the older rocks. The Drift-beds are, as a rule, very irregularly stratified.

It may thus be inferred that the minor details of surface configuration and the soils are, to a certain extent, independent of the underlying older rocks, and are in great measure determined by these drifted materials. In these respects this division differs from the two preceding ones. But while it depends to so great an extent for its soils and topography upon a single formation, there is not in these the great monotony that might be looked for on this account. The Drift itself is composed of materials which offer varying degrees of resistance to denudation, and considerable inequalities of surface result from this circumstance. In addition to this, the older rocks had been greatly eroded before they were covered by the Drift, so that the general contour of the country, as well as many of the most prominent topographical features in this division, are quite independent of the superficial Drift-coating which determines so many of the minor details.

The low trough of the Prairie region, the rugged hills of the Buhr-stone, and the gently undulating surface of the Southern pine belt were features of the landscape before the deposition of the Drift; and similarly with the soils the Drift itself yields a number of varieties, which are still further increased by the modifications brought about by their intermixtures with the disintegrated portions of the underlying country rocks. These rocks are referred to two principle formations, the Cretaceous and the Tertiary. For convenience of reference I give in condensed form the most important subdivisions of these formations, together with their lithological and other characters in so far as they are of importance in determining the agricultural features.

TERTIARY.—*Vicksburg* (uppermost).—The chief material is a soft white limestone (containing *Orbitoides Mantelli*), easily cut with an ax or a saw into blocks, which are used throughout the region of its occurrence in the construction of chimneys. This alternates with whitish shell marls, and occurs over a belt of country from 30 to 50 miles wide north and south, the lower half of which is gently undulating, the up-

per somewhat broken and hilly. The whole region is covered with beds of later age, which, in most cases, form the soils.

Jackson.—An impure limestone or calcareous clay of a light, nearly white color, containing grains of greensand, is the chief material of this formation in Alabama. Its thickness is from 40 to 50 feet, and in some places it is underlaid with fossiliferous sands and with ten feet or more of grayish laminated clays. The disintegration of the principal stratum gives rise to the calcareous prairie soils of the Lime-hills, whose surface distribution is the same as that of the northern half of the Vicksburg. Like the preceding, the strata of this group are generally covered with beds of a more recent formation, which form the greater part of the soils, and in great measure determine the topography; yet where these overlying beds have been partially removed the characteristic soils and no less characteristic topography of the Lime-hills are produced.

Claiborne.—The materials of this division consist of sandy shell deposits, alternating with impure whitish limestones or calcareous clays containing greensand. These deposits are exposed along ravines and bluffs, but seldom form the surface over any considerable area, and have comparatively little effect upon the soils beyond making them locally more fertile. These beds may be observed at the lower levels throughout the territory above assigned to the Jackson group.

Buhr-stone.—Siliceous sandstones and claystones make up the greater part of this division. These deposits form a line of rocky hills extending nearly across the State. In general, the soils are extremely poor; but there are limited areas of more fertile character, due to the influence of the calcareous beds, with which the prevailing materials are sparingly interstratified.

Lagrange or Lignitic.—Grayish or dark-colored laminated clays and yellowish or gray sands, containing several beds of lignite and alternating with beds of greensand marl. These materials form the substratum of a belt of 15 or 20 miles in width, the soils of which are mostly derived from the superficial beds of Drift, except where the marl beds,

especially along the southern border of this division, give rise to highly fertile Lime-hills, closely resembling those of the Jackson group.

Flatwoods.—The chief strata are "massy" or thick-bedded joint-clays of gray or darker colors, and of tolerably uniform character. The soils are heavy and clayey, seldom tempered to any considerable degree by the sandy beds of the Drift. The timber is mostly post oak.

CRETACEOUS.—*Ripley.*—Hard crystalline and often sandy limestone and bluish, micaceous, frequently highly fossiliferous, marls make up the greater part of this division. The Blue Marl has its best development in the eastern part of the State. The interstratification of the hard limestone with the softer marls give rise to the rugged topography of the Hill Prairie region. The larger proportion of the soils over this division are derived from the Drift, with local modifications due to the influence of the marls and limestone, while occasionally the soils are derived almost wholly from the Cretaceous material.

Rotten Limestone.—An impure argillaceous limestone of great uniformity of composition over wide area is the characteristic material of this division. The surface is gently undulating, and the soils are derived partly from the simple disintegration of the limestone and partly from admixtures of this with the loam of the Drift. This rock underlies a belt of country averaging 15 or 20 miles in width, and is noted for its fertility.

Eutaw.—The chief materials of the Eutaw group are gray laminated clays, irregularly bedded sands, containing some mica, and having often a greenish cast, partly from grains of greensand and partly from some substance coating the siliceous sand grains.

Subordinated to the above are beds of lignite and lignitized trunks of trees. The soils over the whole area are derived from the overlying Drift, except along the sides of ravines, etc., where the above named materials are uncovered, giving rise to small tracts of more than average fertility, which lie, however, usually on such steep slopes as to be of little agricultural value. The stratigraphical relations

of these formations are shown in sufficient detail in the general section given on page 181.

Taken as a whole, the surface of the Southern Division has a general slope from the margin of the two divisions just described outward, *i. e.*, west and south toward the Mississippi basin and the Gulf of Mexico. This general slope is interrupted by the trough of the Central Prairie region, which is depressed many feet below the general level both north and south of it, and also on a limited scale by the trough of the Flatwoods. South of the prairie belt there is a line of rocky hills made by the hard sandstones and claystones of the lower part of the Tertiary formation, beyond which, toward the south, the country falls away very gradually and uniformly to the coast.

Mention has been made of the differences existing in the materials of the Drift formation overlying the most of this region. These materials are pebbles, sands, and a red, brown, or yellow loam, and the geographical distribution of these several materials, taken in connection with other physical conditions, lies at the basis of the classification of this division into its agricultural regions.

Around the outer margin of the two preceding divisions there is seen a great accumulation of these Drift beds, so great as to hide completely from view over areas of considerable size all the underlying rocks of the country. Along this belt pebbles of quartz and chert and beds of red and brown loam are seen in their greatest thickness. As we go outward from this belt the pebbles become less and less abundant, and seem to be confined to well-defined channels, along which, however, they may be traced for great distances, even into Florida, but they cease to be characteristic beyond a comparatively narrow belt. The loam also appears to decrease in thickness and prominence in the same directions, though it is found generally distributed much farther south than the pebbles.

The whole region over which the red and brown loams prevail has many topographical and botanical features in common, prominent among which are the broken and hilly surface and the mixture with pines of oak and hickory in the forest growth. Southward from this region of mixed

growth the long-leaf pine is the most characteristic and constantly occurring tree, and gives the name to a second region which reaches to the Gulf of Mexico.

The subdivisions of the region of mixed growth are based primarily upon the species of pine which is associated with the other trees, it being the short-leaf pine in the one case and the long-leaf in the other. Other subdivisions of this region depend on the relative proportions of long-leaf pine and other timber trees.

The region of the long-leaf pine is subdivided, in accordance with the prevailing topographical character, into hilly, rolling, and flat lands.

The Black-Prairie region, the Flatwoods, and the Lime-Hills, are agricultural regions, in which the soils are to a great extent dependent on the rocks of the country for their formation, and do not properly find a place in the two regions as just defined.

In accordance with the characters given, the Southern Division may be divided into the following Agricultural Regions or Subdivisions:

1. *The Oak and Pine Uplands Region*, includes—
   The Oak and Hickory and Short-leaf Pine Uplands.
   The Gravelly Hills, with Long-leaf Pine.
   The Oak and Hickory Uplands, with Long-leaf Pine, including Brown-Loam Uplands, and Long-leaf Pine Uplands.
2. *The Central or Upper Prairie Region*, with its three features of—
   Black Prairie or "Canebrake."
   Hill Prairie or Chunnenugga Ridge.
   The Blue Marl Lands.
3. *The Post-Oak Flatwoods.*
4. *The Lower Prairie or Lime-Hills Region*, including the shell prairies and red-lime lands.
5. *The Long-leaf Pine Region*, with its subdivisions—
   Long-leaf Pine Hills.
   Rolling, Open Pine Woods and Lime-sink Region.
   Pine Flats.
6. *The Alluvial Region of Mobile River and the Coast Marshes.*

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From the nature of the forest growth, as outlined in the above agricultural subdivisions, it may be inferred that the prevailing soil varies with the geographical position, and in fact we find that the surface soil increases in sandiness as we go southward toward the Gulf. In addition to this, local variations in the predominant soil of all the regions just enumerated arise from the varying quality at different depths of these superficial beds of loam and drift. To illustrate this a series of specimens was taken near the city of Tuscaloosa down to the depth of 14 feet, passing through the red loam and into the underlying sand and pebble beds.

No. 115. *Soil*, brownish-red color, taken to the depth of 5 inches.

No. 116. *Subsoil*, clayey loam, of a deep-red color, taken from 5 to 18 inches.

No. 117. *Under subsoil*, more sandy, and of same deep-red color, taken from 18 inches to 3½ feet.

No. 118. *Red, sandy loam*, taken from 3½ to 7½ feet.

No. 119. *Reddish sandy loam*, increasing in sandiness with the depth, and becoming yellowish in color; taken from 7½ to 9½ feet.

No. 120. *Yellowish, coarse sand*, taken from 9½ to 14 feet. The preceding bed gradually passes into this.

No. 121 *is a bed of pebbles with sand*, irregularly stratified, and of variable thickness and quality, extending to the bottom of the gully, say from 14 to 45 feet. This has not yet been analyzed.

No. 122. *Gray clay, with a few specks of red.*—This was an irregularly-shaped bed near the bottom of the section.

These specimens were analyzed by Mr. D. W. Langdon, jr., of Mobile, a student in my laboratory, with results as given on the next page:

ANALYSES OF BROWN-LOAM SOIL, WITH SUBSOIL, AND THE UNDERLYING BEDS, DOWN TO THE DEPTH OF 14 FEET; ALSO, ANALYSIS OF GRAY CLAY, TUSCALOOSA.

	Soil brownish-red to depth of 5 inches.	Subsoil deep-red from 5 to 18 inches.	Under subsoil deep red 18 inches to 3½ feet.	Red, sandy loam, more yellowish than preceding, 3½ to 7½ feet.	Red, sandy loam, becoming yellowish below, 7½ to 9½ feet.	Yellowish, coarse sand, 9½ to 14 feet.	Gray clay, with a few specks of red, bottom of gully.
	No. 115.	No. 116.	No. 117.	No. 118.	No. 119.	No. 120.	No. 122.
Insoluble matter	81.683	84.777	91.493	88.989	96.405	98.370	81.837
Soluble silica	0.465	0.656	0.066	1.827	0.687	0.086	0.256
	82.148	85.433	91.559	90.816	97.092	98.456	82.093
Potash	0.255	0.205	0.150	0.139	0.005	0.005	0.256
Soda	0.175	0.175	0.140	0.135	0.004	0.003	0.197
Lime	0.140	0.065	0.071	0.045	0.006	0.004	0.341
Magnesia	0.097	0.100	0.005	0.004	0.002	0.001	0.194
Brown oxide of manganese	0.102	0.099	0.066	0.061	0.003	0.002	0.010
Peroxide of iron	4.184	4.903	2.495	2.592	1.910	0.717	0.576
Alumina	7.081	6.278	3.466	3.998	0.786	0.454	11.314
Phosphoric acid	0.090	0.086	0.007	0.007	0.003	0.001	0.001
Sulphuric acid	0.025	0.083	0.071	0.066	0.004	0 004	0.150
Water and organic matter.	5.425	2.288	1.987	1.791	0.841	0.752	5.140
Total	99.722	99.715	100.017	99.654	100.656	100.399	100.272
Hygroscopic moisture	6.305	7.275	5.647	4.103	3.996	0.290	.....
absorbed at	18 C.°	18 C.°	19 C.°	18 C.°	18 C.°	19. C.°	.....

These analyses show very clearly the gradual decrease in the percentages of potash, lime, magnesia, and phosphoric acid, and consequent deterioration of the soil-forming qualities of the beds as the depth from the surface increases, and a similar decrease in the capacity for moisture in the same direction. The prominent points of difference between the Loam and the Drift sands are best seen on comparing Nos. 118 and 120, since No. 119 forms a transition between the two. This transition bed (No. 119) shows how the lower parts of the Loam and the upper parts of the underlying Drift shade off into each other without there being any sharp line between, and yet within two feet the change from loam to sand is complete.

From the analyses we can also easily account for the fact, so often to be observed in the parts of the State where these beds make the surface, that along many of the slopes of the loam-covered table-lands we find a forest growth entirely different from that of the plains above and denoting a great deterioration in the quality of the soil. A removal by denudation of the loam will expose the greatly inferior sands and cause a corresponding change in the character of the soil. Many of the poor pine ridges which traverse the areas of better land have had this surface loam in great measure removed. On the other hand, the sandiness of the soils of some of the table-lands finds its explanation in the fact that on such level lands the surface materials are not washed off bodily, but the finer clayey particles are carried away by the water, leaving the coarser sand behind. In most cases of this kind the surface soil is usually much more sandy than its subsoil.

The specimens of which the analyses are given were taken from a slope where both the finer clayey and the coarser sandy particles of the loam would be washed away together by the rains, thus preserving at the surface nearly the original proportions bntween the two.

In the following detailed descriptions of the agricultural regions of this southern part of the State, these general principles will find many applications.

THE OAK AND PINE UPLANDS REGION.

This region, with its subdivisions, embraces an area of 16,915 square miles, and includes some of the best uplands of the State. Its two principal subdivisions, as already stated, are named from the species of pine which characterize them. As far north as about latitude 33°30 the long-leaf pine is prevalent; farther north it is the short-leaf species. The northern and eastern margins of this region (lying next to the preceding general divisions) are well characterized by the accumulation of flinty pebbles.

The soils along this gravelly belt are not materially different from those of the other parts of the Oak and Pine Uplands, except that they are, in general, rather poorer and more sandy; but since a line of gravelly hills, timbered with oaks and long-leaf pine, runs along the border of the metamorphic or crystalline rocks through South Carolina and Georgia into Alabama with substantially the same characters, this division is here retained.

OAK AND HICKORY UPLANDS, WITH SHORT-LEAF PINE.

This region includes the whole or parts of Lauderdale, Colbert, Marion, Lamar, Fayette, Tuscaloosa, and Pickens counties, with an area of about 4, 135 square miles. In its soils and topography it is so closely connected with the next two regions that a special account of the same would involve much repetition. Along the eastern margin of this region there are some modifications of the soils, brought about by the influence of the underlying rocks, which in the three first-named counties belonging to the Sub-Carboniferous formation, and in the others to the Coal Measures. These, however, have not been specially studied, and the larger proportions of the soils may be referred to the red loam, which also in great measure makes the surface of the following regions. Most of the soil varieties occurring in the region next to be described have their representatives here, and the analyses there given will show their general characters in this section also.

GRAVELLY PINE HILLS, WITH LONG-LEAF PINE.

This subdivision occupies a belt of varying width, but averaging perhaps 30 miles, bordering on the south and west the older formations of the State (Metamorphic, Silurian, and Carboniferous) and hiding the line of contact between these and the Cretaceous formation. This belt stretches from Lauderdale county, on the northwest, to Russell county on the east, and includes the following counties and parts of counties: The western parts of Lauderdale, Colbert, Franklin, Marion, Lamar, and Fayette; nearly all of Pickens, Tuscaloosa, and Bibb; northern Greene, Hale, Perry, and Dallas, southern Chilton, nearly all of Autauga, southern Elmore, and Tallapoosa; northern Montgomery, most of Macon and Russell, and southern Lee.

Within these limits there are about 6,170 square miles in which the Drift beds conceal completely the underlying rocks, and 2,650 square miles in which these surface beds make the greater part of the soils and the older rocks show only along the water-courses. The whole area in which the Gravelly hills, with short-leaf and long-leaf pines characterize the country, may thus be placed at about 8,820 square miles. But since these Gravelly hills with short-leaf pine timber in the northwestern part of the State present no very clearly marked points of difference from the short-leaf pine uplands of Mississippi, into which they gradually pass, it is only that portion of the Gravelly hills with long-leaf pine that is to be considered under this head. With these limitations, therefore, this region embraces parts of the counties of Tuscaloosa, Pickens, Greene, Hale, Bibb, Perry, Dallas, Chilton, Autauga, Elmore, Montgomery, Tallapoosa, Macon, Lee, and Russell, with an area which has been estimated at 4,685 square miles.

General Characters.—As the name indicates, this subdivision has a rather uneven, hilly surface, especially where the table-lands break off toward the water-courses. Between these there are often tolerably wide tracts of nearly level land. The hills are, in general, clothed with a growth of upland oaks, among which the pines are usually conspicuous.

The surface over most of this territory is formed of beds of red or yellowish loam varying in thickness from a few inches to 25 feet. This loam is, in general, devoid of lines of stratification, and overlies beds of sand and pebbles, which are very distinctly stratified, although the stratification is extremely irregular. All these beds rest upon a worn or eroded surface of the older rocks, and on this account the thickness varies considerably. In many parts of the region the sands and pebbles have been cemented together into pretty solid rocks by the iron which is so generally present as coloring matter. These are the only hard rocks belonging to the surface beds. In some parts of the more northern counties, and in Tuscaloosa, these pebbly conglomerates act an important part in the production of topographical features, and in most of the region the hills, and even slight elevations, will be found to be capped with a sheet of ferruginous sandstone formed in this way, and giving rise to the elevation by protecting the strata from washing away. Wherever the red colored sands and beds of pebbles rest upon a sheet of impervious clay, the conditions for the formation of these rocks exist.

AGRICULTURAL FEATURES.—The Red or Yellow Loam, above mentioned as overlying the stratified sands and pebbles of the Drift, forms all the best upland soils of this region; but in places the underlying sands occupy the surface, forming very light soils, which may produce well for a while, but are soon exhausted. Between these two extremes there are many grades of soils resulting from their intermixtures. The Loam, as above stated, with a variable thickness, overlies the Stratified Drift where the thickness is considerable; from two or three feet upward, the soils have the usual character of those of the brown-loam uplands. When fresh they will yield under good cultivation from 1,000 to 1,200 pounds of seed cotton to the acre, but they soon fall off in productiveness. Between the streams the country has the character of plateau or table-land, and is not much broken or hilly. The following analyses will show the general nature of the uplands and table-lands soils:

No. 6. *Upland sandy loam* (second class table-lands) from

four miles east of Prattville, Autauga county, collected by Dr. S. P. Smith. The somewhat sandy top soil is underlaid to the depth of 20 feet by red clayey loam, below which is a coarse yellow sand alternating with clay. Depth, eight inches; vegetation, short-leaf pine, red and post oaks, hickory, dogwood, black gum, chestnut, persimmon, etc.; color, yellowish-brown on surface, passing into light-red below.

No. 57. *Brown-loam soil* from near Mulberry post-office, Autauga county, collected by T. D. Cory. Depth, six inches; vegetation, one-third pine, with white, post, and red oaks, hickory, dogwood, and black gum; color, light brown, changing below six inches to dark-red. The fresh land will yield from 800 to 1,200 pounds of seed-cotton to the acre, but after several years' cultivation the yield is reduced to 200 or 400 pounds.

No. 60. Subsoil of No. 57. Depth, six to twelve inches; color, dark-red.

Where the table-lands break off in the direction of the water-courses the top stratum of red loam becomes thinner, and in places is entirely removed, leaving the underlying sands at the surface. In the latter case the lands are scarcely worth cultivating, except in the creek bottoms, and even here the thin sandy soils with sandy subsoils are very soon exhausted. About a third of the tillable lands in the pine woods have a subsoil of greater or less thickness of this red loam, and though the soil is thin, it is moderately profitable to cultivate, because of the clay subsoil. The character of this variety of pine lands will be seen from the following analyses:

No. 3. *Upland pine-woods soils* near Prattville, Autauga county. Depth, eight inches; vegetation, long-leaf pine, hickory, red, post, and black-jack oaks, dogwood, persimmon, etc.; color, ashey-gray at top, changing to yellowish in subsoil. The fresh land will yield 400 pounds of seed-cotton to the acre.

No. 4. Subsoil of No. 3, Autauga county. Depth, 12 to 18 inches; color, yellowish. Soil and subsoil collected by Dr. S. P. Smith.

Lands of the Gravelly Hills, Autauga County.

	Long-leaf pine lands—brown loam.			Long-leaf pine lands—sandy.	
	Upland sandy loam near Prattville.	Brown sandy loam near Mulberry.		Uplands pine woods.	
	Soil.	Soil.	Subsoil.	Soil.	Subsoil.
	No. 6.	No. 57.	No. 60.	No. 3.	No. 4.
Insoluble matter	89.100	91.510	84.520	94.170	88.860
Soluble silica	2.840 } 91.940	1.960 } 93.470	4.620 } 89.140	1.390 } 95.560	3.380 } 92.240
Potash	0.073	0.115	0.136	0.040	0.111
Soda	0.018	0.004	0.010	0.006	0.029
Lime	0.060	0.057	0.109	0.069	0.047
Magnesia	0.061	0.140	0.172	0.052	0.139
Brown oxide of manganese	0.122	0.027	0.171	0.117	0.125
Peroxide of iron	1.577	1.527	2.422	0.744	1.572
Alumina	4.350	0.943	6.078	0.603	4.320
Phosphoric acid	0.077	0.042	0.078	0.062	0.077
Sulphuric acid	0.034	0.013	0.074	0.009	0.002
Water and organic matter	2.206	2.888	2.477	2.807	1.660
Total	100.518	99.226	100.867	100.069	100.322
Hygroscopic moisture	3.882	2.905	5.39	1.916	6.079
absorbed at	16 C.[a]	28 C.[a]	29 C.[a]	24 C.[a]	19. C.[a]

The analyses of brown-loam soils show deficiencies in the principal elements of plant-food, potash and phosphoric acid, and also in lime, showing these to be essentially inferior soils. There is an important difference, however, between the soil and subsoil (Nos. 57 and 60) in their retentiveness of hygroscopic moisture, as shown by the determinations, and the subsoil is also somewhat richer in lime and in plant-food than the top soil. Deep plowing is, therefore, at once suggested as a means of improvement. Manures will be well retained both by subsoil, No. 60, and by loam soil, No. 6, which is intermediate in composition and physical properties, between soil No. 57 and its subsoil. In the pine-woods lands the soil is seen to be lacking in all the elements of fertility, being composed mostly of sand, with very slight retentive power. Stimulant manures will do little good except for a very short time. For permanent improvement nutritive manures are necessary. The subsoil is superior in all respects to the top soil, and deep plowing will be attended with good results. The absorptive power of this subsoil is quite marked for so sandy a material, and this property, probably more than anything else, makes it possible to cultivate such soils with any profit.

In some parts of this region there is a kind of pond lands, which, when drained, will produce very well for a year or two, but are then apparently completely exhausted. The accompanying analyses shows its chemical nature:

No. 61. *Pond-land soil* (exhausted), near Mulberry, Autauga county, collected by T. D. Cory. Depth, 12 inches; vegetation. mostly sweet gum; color, a dark gray.

POND-LAND SOILS (EXHAUSTED) NEAR MULBERRY, AUTAUGA COUNTY.

	No. 61.	
Insoluble matter	78.630	84.675
Soluble silica	6.045	
Potash		0.193
Soda		0.094
Lime		0.019
Magnesia		0.198
Brown oxide of manganese		0.079
Peroxide of iron		1.810
Alumina		7.951
Phosphoric acid		0.076
Sulphuric acid		0.132
Water and organic matter		6.101
Total		100.328
Hygroscopic moisture		7.697
absorbed at	27.8 C.°	

In this soil it would appear that a deficiency in the lime is the chief cause of its rapid exhaustion, and liming is the first improvement indicated. It is lacking also in potash and phosphoric acid.

The bottom soils of this region vary with the surrounding uplands, and are, as a rule, easily cultivated and quite fertile, as they contain the best portions of the soils of the uplands. The second bottom or hummock soils are, in great measure, similar, to the upland soils, but are usually somewhat stronger. The best farming lands in the region are to be found in the river hummocks or second terraces, and the general character of both will be seen from the following analyses:

No. 9. *Alabama River First-Bottom Soil*, four miles west of Montgomery, in Autauga county, collected by Dr. S. P. Smith. Depth, 8 inches; vegetation, red and white oaks, poplar, beech, hickory, sweet gum, elm, slippery elm, walnut, wild cherry, ash, sourwood, dogwood, grapes, and muscadines; color, light-brown top soil, with yellowish subsoil.

No. 20. *Warrior River Hummock or Second-Bottom Soil* (virgin), plantation of James R. Maxwell, near Tuscaloosa, collected by James R. Maxwell. Depth, six inches; vegeta-

tion, originally a dense cane thicket, with some sweet gum and red oak; color of the top soil, a light to dark-brown, changing at the depth of 10 inches to a reddish-brown. The fresh land will produce 1,000 pounds of seed-cotton, or from 50 to 60 bushels of corn, to the acre.

No. 66. *Warrior River Hummock Soil* from the same locality as the preceding, but taken to the depth of 14 inches.

No. 21. *Warrior River Hummock Soil* (cultivated twenty years) from the same locality. Depth, 14 inches; vegetation, same as No. 20.

No. 22. *Warrior River Hummock Subsoil*, subsoil of Nos. 20, 21, and 66. Depth, 14 to 24 inches; color, reddish-brown.

Nos. 20, 66, 21, and 22 were collected by James R. Maxwell.

FIRST AND SECOND BOTTOM LANDS.

	AUTAUGA COUN'Y	TUSCALOOSA COUNTY.			
	Bottom lands, Alabama river.	Hummock lands, Warrior river.			
	First-bottom soil.	Virgin soil to depth of 6 inches.	Virgin soil to depth of 14 inches.	Soil after 20 years cultivation, to depth of 14 inches.	Subsoil of the three preceding; depth, 14 to 24 inches.
	No. 9.	No. 20.	No. 66.	No. 21.	No. 22.
Insoluble matter	77.080	73.995	69.900	73.339	71.227
Soluble silica	6.037	6.518	10.987	8.777	10.665
	83.117	80.513	80.887	82.116	81.892
Potash	0.335	0.252	0.448	0.383	0.504
Soda	0.189	0.052	0.033	0.052	0.196
Lime	0.136	0.468	0.342	0.314	0.241
Magnesia	0.303	0.429	0.547	0.502	0.516
Brown oxide of manganese	0.384	0.006	0.190	0.041	0.081
Peroxide of iron	5.357	4.395	5.303	4.590	10.254
Alumina	4.841	5.182	6.004	5.288	2.105
Phosphoric acid	0.137	0.274	0.325	0.214	0.284
Sulphuric acid	0.040	0.071	0.072	0.072	0.034
Water and organic matter	5.230	8.893	6.311	6.617	4.490
Total	100.069	100.535	100.463	100.189	100.597
Humus	1.047	2.310	.....	.....	.....
Available inorganic	0.862	1.255	.....	.....	.....
Available phosphoric acid	0.058	0.112	.....	.....	.....
Hygroscopic moisture	8.193	18.811	8.707	15.836	14.016
absorbed at	17.2 C.°	17 C.°	29 C.°	20 C.°	17 C.°

By its composition the bottom soil is seen to be an excellant soil, and the large crops, especially of corn, which it produces, are what might be expected from an inspection of the analysis. It is liable to overflow in many parts, and is, therefore, less planted in cotton than in grain.

The hummocks are also good soils, having, above the average content of phosphoric acid, a good supply of potash, and a sufficient quantity of lime to make these ingredients available. In comparing the analyses we find that the percentage of phosphoric acid and potash increases with the depth, while the lime decreases in quantity, it being greatest at the surface. They are all sufficiently retentive of moisture, and will hold manures well. The cultivated soil, No. 21, is very little inferior to the virgin soil in the elements of fertility, and the observed difference in the productiveness of the two is doubtless due to the circumstance that the fresh soil contains plant-food in a more easily available form.

It is a matter of experience that when the top soil has been washed off, as, for instance, on the low knolls, the reddish-brown sub-soil appears to be, for a time at least, almost barren. This, as we see from the analysis, cannot be due to any deficiency in the elements of plant-food, and must therefore be owing to the physical and chemical conditions of the material, to its compactness, want of vegetable matter, and perhaps also of lime, to render available the plant-food which it actually contains. Thorough breaking up, plowing in of green crops, and applications of lime would undoubtedly in a very short time make this subsoil quite as productive as the soil.

The humus determination of the virgin soil, No. 20, shows 0.112 per cent. of available phosphoric acid, a very large proportion of the total amount present.

OAK AND HICKORY UPLANDS, WITH LONG-LEAF PINE.

The belt of country lying between the Central Prairie region on the north and that of the Long-leaf Pine region on the south, is characterized by the almost universal presence of the long-leaf pine among the timber trees, but with it, in the upper part of the belt, are associated the upland

oaks and hickories in perhaps equal proportions, but diminishing in frequency southward, and thus forming a transition into the Long-leaf pine region proper. Under this head are embraced parts of the following counties: Sumter, Choctaw, Clarke, Marengo, Wilcox, Monroe, Conecuh, Butler, Crenshaw, Covington, Coffee, Pike, Montgomery, Bullock, Barbour, Dale, and Henry, and the area included is about 8,095 square miles.

While the upper and lower parts of this division in their extreme characters differ widely, they nevertheless shade off imperceptibly into each other, and it is not possible, except in a general way, to draw the line between them. In the upper half the prevailing soils are brown sandy loams, with a growth of upland oaks and hickories and some short-leaf and long-leaf pines; in the lower half the soils are more sandy, and the timber consists largely of long-leaf pine, along with black-jack oak and others which usually affect sandy soils. It will be most convenient to speak of this region under the two heads of *brown-loam uplands* and *pine uplands*, bearing constantly in mind the fact that these names merely serve to call to mind the predominant characters of the two sections, and that in each there are tracts of greater or less extent which have all the distinctive marks of the other.

1. Brown-Loam Uplands.—This section forms the upper or northern half of the region which we are describing, and embraces parts of the counties of Sumter, Choctaw, Clarke, Marengo, Wilcox, Monroe, Butler, Crenshaw, Montgomery, Pike, Bullock, Barbour, and Henry, with an area which is approximately 4,105 square miles.

The Lignitic or Lower Tertiary strata which underlie this whole section, consist of laminated clays and sands, to which are subordinated beds of lignite, and of shell marls often containing a high percentage of greensand or *glauconite*.

The two halves of this section, however, differ very materially from each other in the prevailing character of these Tertiary beds. Towards the east, in Butler, Crenshaw, Pike, Bullock and Barbour counties, they are mostly of marine nature, and consist of sandy materials often highly fossiliferous, and of calcareous strata.

Westward from Butler county the lignitic character of the beds become more pronounced, laminated sands and clays making up a very large proportion of the strata. These underlying beds, however, both east and west, are in most cases at such depths below the surface as to exercise comparatively little influence upon either soils or topography, which are mostly, as will be seen below, determined by the superficial beds of another formation.

There, are, however, some notable exceptions to this, which deserve mention.

1st. The laminated lignitic clays which lie at the very base of the Tertiary formation attain a very great thickness in the western half of the section we are now considering, and from the Alabama river, just below Prairie Bluff, out to the Mississippi line, they form the surface, from which the Drift beds have been removed, along a belt five or six miles wide, and called from its topographical and other characters the "Post-oak Flatwoods." This agricultural division will be more specially described beyond.

2d. The marine beds above mentioned as interstratified with the lignitic, and which consist of shell marls often containing a large percentage of greensand, are in many places, in consequence of the removal by denudation of the overlying superficial deposits, brought near the surface, modifying, and in some cases even forming, the soil.

The reaction of the greensand deposits upon the loam often produces a soil remarkable for its deep-red color and for its fertility. These soils occur in detached bodies in the brown-loam uplands, and have been observed more frequently in the eastern part of the region, though occurring probably in all parts of it. Near Clayton, in Barbour county, and Greenville, in Butler, are characteristic occurrences. The top soil is usually reddish-brown, and the deep-red color is better seen in the subsoil. The vegetation consists of Spanish, white, red, black, and post oaks, hickory, short-leaf pine, sweet gum, sour gum, dogwood, persimmon, chestnut, and chincapin. When fresh, such soils will produce 1,000 pounds of seed-cotton or 20 bushels of corn to the acre. A partial analysis of a red soil from near Greenville shows some 97 per cent. of insoluble matter in the top soil,

which is quite high for so good a soil, but the loamy character of the subsoil remedies this defect.

In the western counties of this region, Monroe, Wilcox, Clarke, Marengo, and Choctaw, where the lignitic clays are so largely developed, the reaction between them and the marl beds produces a different kind of soil, viz., a calcareous clayey, prairie, or "lime-hills" soil.

The best display of these hills is probably seen between Choctaw Corner and Lower Peach Tree. The marl-bed containing greensand is there at least 100 feet above the general drainage, and has, both above and below it, laminated gray clays, in the lower part of which occur one or two thin seams of lignite. The country is very much broken, and in this respect bears a striking resemblance to the lime-hills region of southern Clarke, etc.

The drift beds have been generally removed, and the soils mostly come directly from the disintegrated clays and the associated marls. The most characteristic soil is a heavy clayey loam of a yellowish-gray color with a slightly greenish tinge. Where the drift loam is present the color is more decidedly red and the soil more sandy; and where this loam is absent, and the marl is least felt, the crumbling clays yield a heavy, dark-colored argillaceous soil. The vegetation is chiefly beech, which grows both on the hills and in the bottoms. With it are associated hickory, pignut, white and Spanish oaks, sweet gum, ash, popular, sourwood, holly, sour gum, cucumber trees, numerous spruce or swamp pines (*P. glabra*), and a few short-leaf pines. These hills are very generally cleared and in cultivation, which is proof of their fertility. Their usually steep slopes are, however, soon denuded of soil, and where turned out they are rapidly cut up by deep and unsightly washes.

A lime-hills soil of this section was collected in Wilcox county, about ten miles west of Lower Peach Tree, of which the analysis is given below.

No. 140. *Lime-hills soil*, 10 miles west of Lower Peach Tree, Wilcox county. Depth, eight inches; color, yellowish-gray, with a slightly greenish tinge; vegetation, chiefly beech, but mixed with hickory, white oak, sweet gum, a few short-

leaf pines and *Pinus glabra*, ash, some Spanish oak, poplar, pig-nut, sourwood, cucumber trees, holly, and sour gum.

LIME-HILLS SOIL, WILCOX COUNTY.

	No. 140.	
Insoluble matter	75.550	76.684
Soluble silica	1.134	
Potash		0.174
Lime		0.184
Magnesia		0.014
Brown oxide of manganese		0.032
Peroxide of iron		5.545
Alumina		7.772
Phosphoric acid		0.229
Sulphuric acid		0.060
Water and organic matter		8.922
Total		99.616
Hygroscopic moisture		17.067
absorbed at		10.5 C.°

In this soil the percentage of phosphoric acid, as also the hygroscopic moisture, is high; the lime and potash sufficient.

The three most important of these green sand and marl beds are—1st. The *Nanafalia marl*, appearing on the Tombigbee, at the landing of that name, and on the Alabama, at Black's and Gullett's Bluffs. This marl contains a large per centage of greensand, and its analysis is given below under the section treating of fertilizers. The most characteristic feature of this marl deposit, is the occurrence in it of heavy beds made up almost exclusively of a small shell of the oyster family. (Gryphea Thyrsæ). This marl produces prairie spots, or lime-hills in the vicinity of Luther's Store, in Marengo county, and across that county in the direction of Black's Bluff. On the east side of the Alabama river it characterizes a great deal of the low lands near the mouth of Pursley and Gravelly creeks, and probably also in other parts of southern Wilcox.

The second of these beds—the *Bell's Landing marl*—appears also near the top of the bluff at Lower Peach Tree, and on the eastern side of the Alabama river contributes to the formation of some of the limy soils in the upper part

of the course of Flat Creek in Monroe county, and of similar soils in the northern part of Conecuh. West of the Alabama river a belt of lime-hills extending westward in Clarke county, in the direction of Choctaw Corner, and from which the soil was taken whose analyses has just been given, owes its existence to this marl.

In Choctaw county the limy hills north of Butler are also derived from this bed.

The third—or *Wood's Bluff marl*—appears at the Bluff so named on the Tombigbee, and at Johnson's Landing, below Bell's, on the Alabama. This marl bed and the preceding are separated from each other by only about fifty or sixty feet of lignitic clays and sands, and their lines of outcrop across the country, are parallel and close together, the Wood's Bluff bed being southward of the other. Both these are green sand shell marls, and they are both characterized by the occurrence in them of rounded, boulder-like masses of indurated marl, differing from the rest of the bed only in being much harder and less fossiliferous. This indurated bed is a very persistent feature, especially of the Wood's Bluff marl, and is seen at the foot of the mountain just south of Lower Peach Tree; at Choctaw Corner, in Clarke county, and in the town of Butler in Choctaw county, and thence westward into Mississippi. Where circumstances are favorable the softer marl is washed out from beneath this ledge, and caves are produced. Several analyses of the Wood's Bluff marl are given below in the section on fertilizers.

With these exceptions, the superficial beds of loam, sand, and pebbles determine almost exclusively the agricultural and other characters of this whole region.

On account of the almost universal presence of a bed of red or yellowish-red loam overlying the sandier materials of the Drift, the topography of this region is quite varied because of the unequal degrees of resistance thus offered to denudation. The water-sheds are usually of the nature of table-lands, which break off toward the streams in somewhat rugged hills. The Loam rests upon beds of sand and pebbles, as above stated, and hence an abundance in every

part of this region of good freestone water even in the driest seasons.

The agricultural characters of the upland region are determined almost exclusively by the nature of these superficial beds, and the distribution of the soil-varieties will be understood from the following considerations: The rocks of the country were covered with beds of sand, and in some places with beds of pebbles, which in turn were overlaid with a red or brownish-yellow loam of 20 or 30 feet thickness. The latter forms, in most cases, the soils and subsoils of this region, with the exceptions to be noted below. Wherever the thickness of the loam is considerable, say five feet and upward, the water-sheds and territory generally formed by it are mostly of the nature of nearly level table-lands, whose general elevation above the main water-courses is 350 or 400 feet. On these table-lands the soil is usually a brown sandy loam, increasing in stiffness with the depth from surface, and resting upon a subsoil of clay loam of a red or reddish color. The natural growth consists of numerous species of upland oaks, conspicuous among which are the Spanish, post, red, black, and black-jack, hickories, and short and long-leaf pines.

Upon the table-lands there are varieties of soil depending upon the degree of sandiness, and the deterioration in quality is generally marked by the accession of the pines to the oak growth—short-leaf pine first, then the long-leaf pine. Below a certain depth, or within a certain distance of the top of the underlying drift-sands, the loam becomes more and more sandy, making a very gradual transition to the underlying beds. Along the edges of the table-lands, therefore, and in corresponding positions, where the greater part of the loam has been removed, its sandy lower portions, and the sands of the Drift itself, form the soils, which are then of inferior quality, as is shown by the growth, which consists of long-leaf pine and black-jack, or of the former alone. Of this character are the sandy pine ridges which are interspersed with the better table-lands. They have a poor sandy soil, which often produces pretty well for a short while, but is soon exhausted. Between the two extremes

thus accounted for are numerous gradations resulting from their intermixtures.

It should not be inferred from what has been said that everywhere at elevations 20 or 30 feet below the general level of the table-lands the sands of the Drift would be denuded of the Loam and alone form the soils, for both the Drift and the overlying Loam seem to conform more or less to the more prominent topographical features of the country, as if they had been deposited over a surface which had already been eroded in conformity with the present systems of drainage. It is otherwise difficult to account for the fact that we constantly find sometimes 75 or 100 feet below the level of the table-lands terraces of greater or lesser width, having a capping of considerable thickness of the same red loam, underlaid by sand and pebbles, just as is the case on the table-lands themselves; and, even more, the second bottoms of the larger streams often present the same condition of things. At elevations intermediate between these successive plains are the pine ridges. It may be that a part of this is due to the subsequent degradation of the Loam and its re-deposition along the slopes and over the lowlands; but this explanation will not apply to all cases, for we should then always find the greatest thickness of loam at the lowest levels, and we should often find the relative positions of the loam and the sands and pebbles reversed, which is not the case.

The heaviest or stiffest loams are not, as a rule, found on the highest and broadest of the table-lands, but rather along their borders, where exposed to partial denudation, whence it would seem that upon the level table-lands, where the waters flow off slowly, there is a constant tendency toward increasing sandiness in the top soil, caused by the washing away of the finer clayey particles. Along slopes, however, the more rapidly flowing waters remove both the finer clay and coarser sand, and the proportion of these two ingredients originally existing in the loam is preserved.

It often happens that the freshly-exposed loam appears to be rather sterile, but this is due to the physical condition, and not to the inferior chemical composition, as may be seen from analyses made of soils from Tuscaloosa county, given

under "the Gravelly Pine Hills" division. As illustrating the composition of the sandy varieties of these upland loam soils, the following analyses are presented:

No. 94. *Sandy upland loam soil* from near Clayton, Barbour county, collected by Judge H. D. Clayton. Depth, 12 inches; vegetation Spanish and other oaks and hickory; color, light yellowish-gray, with a subsoil a shade more yellow. This soil is extensively cultivated and much prized, but it almost invariably rusts cotton.

No. 84. *Upland loam soil* from near Lawrenceville, Henry county. Depth, 10 inches; vegetation, Spanish and post oaks, with a few black-jacks, hickory, chestnut, sour gum, short-leaf pine, and a few long-leaf pines; long moss on some of the trees; color, light yellowish-gray top soil, deeper yellow below, all resting upon a red clay loam at two to three feet depth.

The composition of the better class of brown-loam soils is illustrated by the following analyses:

No. 18. *Upland brown-loam soil* from five miles southeast of Troy, Pike county. Depth, eight inches; vegetation, red oaks and a few short-leaf pines; color, dark-brown.

No. 19. Subsoil of No. 18. Color, reddish-brown.

UPLAND BROWN-LOAM SOILS (OAK AND HICKORY UPLANDS, WITH LONG-LEAF PINE).

	SANDY LOAM.		BROWN LOAM.	
	Barbour county.	Henry county.	Pike county.	
	Soil.	Soil.	Soil.	Subsoil.
	No. 94.	No. 84.	No. 18.	No. 19.
Insoluble matter	95.091 } 97.004	95.115 } 96.270	91.965 } 93.880	90.960 } 93.385
Soluable silica	1.913 }	1.155 }	1.915 }	2.425 }
Potash	(*)	0.212	0.077	0.150
Soda	0.007	0.096	0.013	0.066
Lime	0.010	0.058	0.112	0.048
Magnesia	0.056	0.039	0.094	0.080
Brown oxide of manganese	0.131	0.128	0.044	0.092
Peroxide of iron	0.603	0.803	1.431	1.574
Alumina	1.386	0.703	1.841	3.197
Phosphoric acid	0.025	0.100	0.109	0.072
Sulphuric acid	0.001	0.016	0.015	0.072
Water and organic matter	0.443	2.009	2.137	1.532
Total	99.666	100.434	99.753	100.258
Hygroscopic moisture	0.878	1.225	2.590	2.826
absorbed at	5.6 C.°	23.3 C.°	19.4 C.°	18.3 C.°

*Undetermined.

The analyses given on page 275 of upland sandy loam soil and subsoil from 2½ miles south of Union Springs, Bullock county, may also be consulted, since they are of essentially the same character, being derived from the loam, but which, on account of their relation to the Chunnenugga ridge, have been presented in connection with it.

A comparison of the four analyses above given with those of the Gravelly Pine Hills north of the prairie region, will show that they are essentially similar soils, as was to have been inferred from the identity of the material from which both classes have been derived. They are all below the average quality, and are more or less deficient in potash, phosphoric acid, and lime. Enough plant-food in them appears, however, to be in an available form to render them all quite productive for a time. No. 18 is remarkably deficient in potash and No. 94 in lime. No. 94 is also greatly deficient in organic matter and in retentiveness for moisture, but the latter defect is partly remedied by the subsoil, which is a rather stiff loam.

The second bottoms of this section, especially those of the larger streams, are among the best farming lands of the State. The analyses of the second-bottom soils from Autauga and Tuscaloosa counties are illustrations in point, although they have been presented under the division of the Gravelly Pine Hills. The following analysis of a hummock soil from the Alabama river is presented as an additional illustration of the character of the second-bottom soils of the brown-loam region:

No. 92. *Second-bottom soil* of the Alabama river, in Black's bend, five miles east of Lower Peach Tree, Wilcox county. Depth, nine inches; vegetation, sweet gum, short-leaf pine, Spanish, red, and white oaks, poplar, haw, and hackberry; color, brown, speckled with red,

SECOND-BOTTOM SOIL OF ALABAMA RIVER, WILCOX COUNTY.

	No. 92.	
Insoluble matter	86.510	89.779
Soluble silica	3.269	
Potash		0.168
Soda		0.074
Lime		0.221
Magnesia		0.055
Brown oxide of manganese		0.184
Peroxide of iron		1.783
Alumina		2.290
Phosphoric acid		0.200
Sulphuric acid		0.073
Water and organic matter		4.510
Total		99.337
Hygroscopic moisture absorbed at	22.2 C.°	5.916

A comparison of this analysis with those of the second-bottom soils of the Alabama and Warrior rivers, previously alluded to, will show that this, while somewhat more sandy, is still a good soil. The proportion of phosphoric acid is large; that of potash adequate; and the large percentage of lime renders the soil thrifty by putting in an available form all the nutritive ingredients.

2. PINE UPLANDS.—We have seen that the lower or southern half of the oak and long-leaf pine uplands is characterized by the predominance of the long-leaf pine among its timber and by the usually broken and hilly nature of its surface. This section embraces parts of Choctaw, Washington, Clarke, Monroe, Conecuh, Butler, Covington, Crenshaw, Pike, Coffee, Barbour, Dale, and Henry counties, and has an area of about 3,990 square miles.

The surface characters of the eastern and western parts of this section are quite different. In the counties of Choctaw, Clarke, Monroe, northern Conecuh, and southern Butler the siliceous rocks of the Lower Tertiary or Buhr-stone formation lie near the surface and give rise to high and rugged rocky hills. In the other counties above named these rocks are more or less deeply covered with the more recent beds of sand and pebbles, and the surface is correspondingly much less broken. In this part of the section the surface is generally undulating, but sometimes it is hilly, particularly

in the vicinity of the water-courses. In such positions, and sometimes along the ridges, the siliceous rocks above spoken of appear at the surface, but they fail generally to have much influence upon the topography.

The drainage area of the Chattahoochee river in Alabama seems to be characterized by a prevalence of sand among the surface materials, and quite extensive areas covered with deep sand-beds are not uncommon, as, for instance, in Dale county, around Ozark, and between that town and Newton. Throughout the entire pine-uplands section, within 25 or 30 miles of the principal streams, pebbles commonly underlie the surface loams, and the size of the pebbles and the thickness of the beds seem to increase with the approach to the stream. Along some of the rivers, as the Chattahoochee, the pebble beds may be followed nearly to the Gulf.

As the name indicates, the long-leaf pine is the prevailing tree over this whole section. Upon some of the poorer ridges this forms almost the only timber, but with it are usually associated black-jacks and high-ground willow oaks, the latter especially where the soil is most sandy. From this, the prevailing timber growth, it may be inferred that the soil is generally a rather poor sandy loam, with subsoil of a similar nature.

Along the northern edge of this belt many of the dividing ridges are of the nature of table-lands, supporting a mixed growth of the long-leaf pine, with post, red, black, and Spanish oaks, in addition to the black-jack. The same mixed growth is frequently seen also where the divides break off toward the water-courses, and in both cases the sandy soil is underlaid at moderate depths by a red clayey loam. Thus the line between the oak uplands and the pine hills is a shadowy one, and each of these divisions sends into the territory of the other spurs often of considerable length. Along the southern edge there is a similar blending of the characters of the pine hills with those of the lime-hills and the undulating pine lands.

Between these two divisions of the pine lands there is much less difference in the soils and natural productions than in the surface topography. The typical sandy loam, both of this and the undulating pine lands, is shown in the

analysis of the soil from near Andalusia, in Covington county. On the other hand, the better class of upland soils in this division approach in composition the oak upland soils of the preceding division, and are sufficiently well represented in the analysis of the soil from near Lawrenceville, in Henry county (brown-loam uplands).

In the division of the Lime-hills there are tracts which have all the characters of the Pine-hills, lying usually upon the higher ridges, as has been fully set forth under that head.

North of the Prairie belt the Gravelly Pine Hills have great resemblance to this division, both in soils and topography, and the composition of the numerous soil-varieties occurring here can be seen by referring to the analysis given under that section. No analyses have as yet been made of any of the soils of this particular division, but the references given will illustrate the composition of all its principal soil-varieties.

The soils of the first and second bottoms are light and sandy, but quite productive, and form the greater part of the cultivated lands in this division, since the uplands are in general too poor for profitable cultivation. Where the red-loam subsoil is near the surface, and the various species of upland oaks are associated with the long-leaf pine, there is, as before stated, a great improvement in the soil, and the land is generally under cultivation; but these areas approach in character the oak uplands, and are, as a body, found in the upper part of this section and on the divides.

UPPER OR CENTRAL PRAIRIE REGION.

This forms a belt running somewhat diagonally across the State, having a width of some thirty miles near the Mississippi line, but narrowing down toward the east, and almost disappearing in Russell county, on the eastern border of the State. The Prairie region includes parts of the following counties: Pickens, Sumter, Greene, Hale, Marengo, Perry, Dallas, Autauga, Lowndes, Butler, Montgomery, Crenshaw, Bullock, Macon, Russell, and Barbour, and embraces an area which is approximately 5,915 square miles.

GENERAL DESCRIPTION AND SUBDIVISIONS.—While under this name are included all those parts of central Alabama where the prairies occur, only a part, and not the largest part, of the area is of the genuine prairie character. As here used, the term "prairie" does not always mean a timberless region, but refers rather to the character of the soil, the most important varieties of which are described further on.

The Cretaceous formation upon which this region is based is in Alabama made up of three parts. The Eutaw group consists of clays and sands, which are for the most part so deeply covered with beds of Stratified Drift as to have little or no influence upon the soils or topography. Overlying this group is a great thickness of an impure argillaceous limestone interstratified with clays, called the Rotten Limestone. The disintegration of these beds gives rise to the true prairie soils. The uniformity in the composition of the Rotten Limestone has its influence on the topography of the region, which is a low trough, with gentle undulating surface, bounded north and south by hills which rise two or three hundred feet above the general prairie level. The monotony of the plain is relieved by the occurrence here and there of ridges and conical hills capped with the pebbles and sand-beds of the Drift, which at one time overspread the entire region. The irregularities of surface produced by the wearing away of the Rotten Limestone itself are comparatively insignificant. In much of this region the rocks lie very near the surface, and large trees are wanting entirely; but, on the other hand, there are many fine groves of oaks, walnut, poplar, etc.

In all the prairie country the surface water is strongly impregnated with lime, and is often insufficient in quantity. For a supply of this necessity recourse is usually had to artesian wells and cisterns, and, for farm purposes, to shallow ponds. Cisterns are dug into the limestone rock, and usually no brick-work is necessary. Wherever the Drift and loam overlie the Rotten Limestone upon the ridges an adequate supply of pure freestone water is always to be had, and these sandy ridges are usually chosen as the sites for dwelling-houses, and often for towns and villages. From

the uniformity of level the waters falling upon this region are very slowly drained away, and much of it soaks into the ground, converting it into a mud, which, when worked up by vehicles, soon renders the roads nearly impassable.

Next above the Rotten Limestone lie the beds of the Ripley group, consisting of hard, sandy limestone, sometimes crystalline, underlaid by strata of bluish micaceous marls. In contrast to the preceding division, the topography of the Ripley group is varied, the surface being more or less hilly, and while the beds of the Stratified Drift nearly always overlie the strata of this group, the country rocks come to the surface in many localities, giving rise to very marked agricultural features. The depressions are mostly filled with the materials of the Drift, mingled more or less with the calcareous matter of the formation, but the limestone makes its appearance at the surface in numerous bald prairie spots, which are usually upon the tops or sides of the hills. The alternations of hard and softer strata make the hills usually rough and precipitous, and in some localities, as in Little Texas, in Lowndes county, the broken character of the country is extreme.

A belt of this hill prairie country usually borders the black prairie region on the south for most of the way across the State, at least from Marengo county eastward. In some places the bald prairie hill tops are a conspicuous feature, as in Lowndes and Montgomery counties, but more commonly the limestone upon the ridges is covered with the Drift, and then the country has the usual characters of the Oak and Pine Uplands. Of such nature is the Chunnenugga ridge, which has its counterpart in the Pontotoc ridge of northeastern Mississippi. These occurrences will be more particularly described under the several counties.

In the eastern part of the State the bluish micaceous marls are exposed (by removal of the superficial Drift) along the drainage slopes of certain streams which flow into the Chattahoochee river, and there is then produced a third class of lands, which characterize the low grounds of the Cowikee and Bear creeks, in Barbour and Russell counties. In this section of the State these blue-marl lands become as characteristic as the black prairie lands of the west, as was

long since remarked by Professor Tuomey. In topography, the blue-marl lands are much like the oak and pine uplands, and the surface soil also is in a great degree composed of the same materials. To bring into prominence these three well-marked agricultural regions I have proposed the following division of the central prairie region:

The Black Prairie or Canebrake region.
The Hill Prairie or (Chunnenugga Ridge, etc.)
The Blue Marl Lands.

The special agricultural characters of each of these divisions will be given under their several heads.

THE BLACK BELT OR CANEBRAKE REGION.

This division of the prairie region is underlaid by the Rotten Limestone before described, and in its topography and soils shows considerable uniformity. From the great thickness of the Rotten Limestone this division is much more widely spread than either of the others, occupying about 4,365 square miles. It is found in all the counties above included in the prairie region, except those on the extreme eastern border of the State—Barbour and Russell—where it is replaced by the blue-marl lands. The general character of the topography has already been given.

Throughout the canebrake or black belt the coating of Drift which so generally overlies all the country rocks of the southern division has been more or less completely removed by denudation, but patches of it are left in places, chiefly upon the ridges and along the slopes, and these play an important part in the production of soil varieties.

(1.) Where the Rotten Limestone lies at the surface unmixed with the Drift, it yields, on disintegration, a gray or greenish-gray clayey, calcareous soil, which becomes black or very dark-colored when mixed with vegetable matter. The subsoil of the cultivated lands is usually of a lighter color than the top soil, and passes gradually into the lime rock at varying depths. A distinction is often made between the uppermost parts of this rock where it has been exposed to weathering, as it then resembles a whitish or chalky clay, quite different from the unchanged rock, which is frequently

spoken of as the blue-marl rock. Where the depth of soil is sufficiently great it supports a varied growth of trees, among which the several species of oaks, ash, gums, walnut, and poplar are prominent.

From the slight elevations the soil has sometimes been washed away, and bald spots are left, where the bare rock often partly forms the surface (bald prairies). Such places are not suitable for cotton, but produce corn and oats very well. The yield of seed-cotton of the fresh black land is variously estimated between 800 and 1,800 pounds, the average of the estimates being about 1,200 pounds. Perhaps not more than one-fourth of the cultivated lands of this particular division have this kind of soil, which has, however, on account of its great and lasting fertility, given character to the entire region. The following analyses of black prairie soils, selected from the different parts of the State, will best show their character:

No. 30. *Black prairie soil* from eight miles northeast of Livingston, Sumter county (on Jones' Bluff road), collected by Dr. R. D. Webb. Depth, 10 inches; vegetation, a few post, red and black-jack oaks, cedar and prairie white oaks; color, black or very dark gray.

No. 32. *Black prairie soil* from the edge of an open prairie two miles north of Livingston, Sumter county, collected by Dr. R. D. Webb. Depth, 10 inches; vegetation, post, red black-jack, and prairie white oaks, cedar, walnut, and cane; color, black.

No. 16. *Black prairie soil* from W. M. Stakeley's, four miles east of Union Springs, Bullock county. Depth, 12 inches; vegetation, post and red oaks and short-leaf pine, haw, and crab-apple; color, black, with yellowish stiff clay subsoil resting on the rotten limestone; color of subsoil, black, passing below six inches into yellowish, waxy clay. In the sloughs and drains of the prairies the cream of the soil collects from time to time, and there is formed a soil of great thickness and strength. The subjoined analysis will show the character of such deposits.

No. 77. *Black prairie slough soil*, eight miles south of Montgomery, Montgomery county. Depth, eight inches; vegetation, chiefly white oak and hickory; color, black.

BLACK PRAIRIE SOILS.

	SUMTER COUNTY.		BULLOCK CO.	MONTGOMERY COUNTY.
	8 miles northeast of Livingston.	2 miles north of Livingston.	4 miles east of Union Springs.	Prairie slough.
	Soil.	Soil.	Soil.	Soil.
	No. .30	No. 32.	No. 16.	No. 77.
Insoluble matter	46.990	81.745	57.831	25.188
Soluble silica	17.920 } 64.910	2.346 } 84.091	10.431 } 68.262	23.792 } 48.980
Potash	0.444	0.205	0.288	0.441
Soda	0.077	0.076	0.027	0.119
Lime	1.961	0.960	0.981	8.678
Magnesia	0.603	0.061	0.802	1.170
Brown oxide of manganese	0.108	0.192	0.452	0.173
Peroxide of iron	6.944	3.843	7.855	7.074
Alumina	12.418	6.168	11.488	15.565
Phosphoric acid	0.102	0.318	0.507	0.201
Sulphuric acid	0.072	0.152	0.030	0.125
Carbonic acid	.....	.....	.....	5.728
Water and organic matter	11.720	4.075	8.036	11.589
Total	99.359	100.141	98.728	99.843
Humus	2.830	2.000	.....	2.460
Available inorganic	0.740	1.430	.....	1.874
Available phosphoric acid	0.060	0.108	.....	0.037
Hygroscopic moisture	1.283	6.042	14.489	19.992
absorbed at	23.3 C.°	27 C.°	17 C.°	7 C.°

All the above are good soils in every particular. The potash and phosphoric acid is adequate in all, and very high in Nos. 16 and 32, as is also the lime. No. 32 is deficient in organic matter, being taken from the edge of an open prairie, and it has also less capacity for moisture.

(2.) While the Drift and Loam have, as a rule, been removed from the Rotten Limestone, there are many places where they still remain, and where they have protected the underlying rocks from degradation, thus producing the sandy ridges and brown-loam table-lands which often so agreeably relieve the monotony of the prairie region. These superficial beds give rise to a variety of soils, which upon many of the ridges do not differ from the loam soils of other localities, since they are formed of the same materials.

Where the loam is mingled with the prairie soils, as is the case along the slopes of the sandy ridges before mentioned, and where they occupy the slight depressions in the limestone, yellow or mulatto soils are formed, upon which the post oak is the most characteristic tree, for which reason they are often called the post-oak prairies. With this tree are also associated the short-leaf pine and some black-jack and other oaks and hickories. All these trees are usually draped with long moss.

The post-oak prairie soils are mostly rather stiff, calcareous loams of yellowish to reddish colors, having a subsoil of red or yellow-clay loam, which sometimes becomes more sandy with increasing depth, but which often retains much the same character down to the unchanged limestone-rock (10 to 20 feet). On account of their position these lands are usually well drained, and with good seasons are of easy tillage. As cotton lands they are perhaps quite as desirable as the black lands above described. The subjoined analysis will show the composition of an average soil of this kind.

No. 17. *Post-oak prairie soil* from Major Wright's, three miles from Union Springs, Bullock county. Depth, 12 inches; vegetation, post oak, draped with long moss, short-leaf pine, hickory, black-jack and some red oaks; color, four to five inches dark gray, then a sticky red clay, and below that a yellowish clay with "lime balls."

POST-OAK PRAIRIE SOIL, BULLOCK COUNTY.

	No. 17.	
Insoluble matter	71.366	83.347
Soluble silica	11.981	
Potash		0.209
Soda		0.016
Lime		0.371
Magnesia		0.290
Brown oxide of manganese		0.055
Peroxide of iron		6.983
Alumina		6.022
Phosphoric acid		0.251
Sulphuric acid		0.073
Water and organic matter		2.888
Total		100.505
Humus		0.718
Available inorganic		2.426
Available phosphric acid		0.015
Hygroscopic moisture		8.574
absorbed at..	16.6 C.°	

From what has been said, it may easily be inferred that there are all grades of soils, from the brown loams of the hills to the pure black prairie soils, and that the post-oak soils represent a medium between the two.

A comparison of the post-oak prairie soil with those of the black prairies shows that the former, as a rule, has a larger percentage of siliceous matter and less of lime and magnesia; differences which might have been anticipated in considering the modes of formation of the two classes. The analysis above shows a want of vegetable matter and a lower capacity for moisture as compared with the black soils; in other respects it is a fine soil. No. 32 (page 269), however, approaches in composition the post-oak soil except as regards lime.

(3.) The bottom soils of this region vary between very wide limits from the stiff black prairie slough lands, like No. 77 (page 269), which result from the concentration of the black prairie soil to light and rather sandy loams, which have usually enough lime to make them very strong and lasting.

HILL PRAIRIES AND CHUNNENUGGA RIDGE.

A belt of varying width of lands of this character is usually found bordering the prairie region on the south, and, as the hill prairies grade on the one hand toward the black prairies and on the other into the brown-loam uplands, it is somewhat difficult to estimate their extent, or indeed, often to decide what shall be included in this division; but, restricting ourselves to the hilly region within which occur lands with very calcareous soils, its area may be given at about 1,000 square miles.

The hard sandy and crystalline limestones to which the hills owe their existence have already been mentioned. They alternate with beds of shaly clays of a yellowish and gray color, and this disposition of the strata gives rise to the characteristic topography of the limy praire hills. The softer clays are easily washed away, and the limestone breaks off with perpendicular faces. The surface beds on the higher levels are the sands and loam of the Drift, and, where the ridges are broad, they exhibit the usual characters of the brown-loam uplands, being timbered with the trees which grow in such localities, such as Spanish, white, post, and red oaks, hickory, short-leaf pine, sweet and sour gums, chestnut, dogwood, persimmon, etc. The broad ridges of this kind are usually water-sheds or divides for long distances. The creeks flowing northward into the Tallapoosa and Alabama rivers, and southward into Pea, Conecuh, Patsaliga, and Sepulga, are divided by the Chunnenugga ridge and its prolongation westward to Lowndes and Butler counties. The thickness of the Drift and Loam stratum varies with the locality, and in many places it is not more than 25 feet. These ridges and plateaus break off toward the black prairies in a series of rugged hills, along the slopes of which the limy clays are encountered soon after the sumits are left. These hills are abrupt knolls, with a surface of yellowish tenacious clay filled with white concretions of lime.

The timber consists of red, post, and Spanish oaks, short-leaf pine, sweet and sour gum, poplar, white oak, hickory, and ash, and all the trees are usually draped with long moss.

In many places the hillsides are bare of vegetation and deeply gashed with gullies, and the surface in such bare spots is often strewn with fossil shells. At a certain stage of drying these clays acquire an extraordinary degree of tenacity, and so clog the wheels of vehicles as to render travel almost impossible. Wherever the sands and loams form the surface the roads are usually very good.

The soils of this region, considered from the point of view of their origin, are of three types: 1. Those derived from the surface beds of Drift and loam. 2. Those based upon the calcareous rocks of the country. 3. Those resulting from the intermixtures of the two preceding.

The soils of the first kind exhibit the usual variations, depending upon the quality of the beds. The surface is commonly formed of a loam of several feet in thickness, resting upon sandier beds, occasionally mixed with pebbles. The broader parts of the ridges have often considerable tracts of level table-lands with the usual characteristic oak upland growth, and this passes into the other extreme of the pine hills, with long-leaf pine and black-jack, with increasing sandiness of the soil. Between these two are many intermediate grades. The brown and yellowish soils are perhaps the most desirable of this class, taking all things into consideration, and in their chemical composition they do not differ materially from the similar soils of the loam in other localities.

A well-defined ridge, which acts as a divide between waters flowing north and south, may be followed without interruption from Wilcox county along the line between Butler and Lowndes, through northern Crenshaw, southern Montgomery, and northern Pike into Bullock. This ridge has its northern face overlooking the black prairies, usually rather steep and abrupt, while southward it slopes away very gradually, merging imperceptibly into the long-leaf pine and oak uplands. In Bullock county this is known as the Chunnenugga Ridge. Its general surface is quite sandy, and a fair estimate of the sandy varieties of the ridge soils may be obtained from the following analyses:

No. 11. *Chunnenugga Ridge soil*, one mile south of Union Springs, Bullock county. Depth, six inches; vegetation,

chestnut, short-leaf pine, red oak, and sour gum; color of the top soil, dark gray, changing at six inches to a lighter gray, and at three feet to a yellowish color.

No. 12. *Chunnenugga Ridge subsoil*, same locality as preceding. Depth, six to 26 inches; color, light gray.

No. 13. *Upland sandy-loam soil*, two and one-half miles south of Union Springs, Bullock county. Depth, six inches; vegetation, Spanish and a few post oaks, short-leaf pine, and huckleberry bushes; color of top soil, gray, with a subsoil of light yellowish-gray color, resting on a reddish-yellow loam.

SANDY SOILS OF CHUNNENUGGA RIDGE, BULLOCK COUNTY.

	NEAR UNION SPRINGS.		ONE MILE SOUTH UNION SPRINGS.
	Soil.	Subsoil.	Soil.
	No. 11.	No. 12.	No. 13.
Insoluble matter	94.770	96.810	93.890
Soluble silica	0.486	1.060	1.878
	95.256	97.870	95.768
Potash	0.156	0.165	0.209
Soda	0.069	0.107	0.134
Lime	0.081	0.110	0.076
Magnesia	0.069	0.035	0.021
Brown oxide of manganese	0.156	0.065	0.065
Peroxide of iron	0.706	0.490	0.883
Alumina	0.733	0.867	1.260
Phosphoric acid	0.101	0.113	0.058
Sulphuric acid	0.057	0.035	0.083
Water and organic matter	2.642	0.550	2.062
Total	100.026	100.407	100.619
Hygroscopic moisture	1.943	0.822	1.842
absorbed at	18 C.°	17 C.°	19 C.°

From the preceding analyses, it will be seen that soil No. 11 does not change very materially from the surface to a depth of twenty-six inches. For so large a proportion of siliceous and insoluble matter, they all show a fair per centage of potash and phosphates, and of lime also, especially the subsoil No. 12. In vegetable matter and capacity for moisture, the two soils stand very well. A comparison of these with some sandy upland soils of a preceding region, will show great similarity, as might have been inferred from

the identity in their origin. All these soils give probably fair returns for a short time, but they can not hold out well.

Of the second class above mentioned, in which the soils are derived immediately from the country rocks, there are two principal varieties:

(1.) The bald prairie hills, in which the calcareous strata approach very near the surface, and the soil proper is of slight depth. This soil resembles the bald prairies of the preceding division to some extent, but the country is more broken, and the hillsides are often badly washed.

(2.) The beeswax hummocks or beeswax flatwoods, the soil of which is a greenish-yellow, clayey material, is timbered with black-jack oaks, or with pines, forming the post-oak beeswax prairies and the beeswax pine lands of some sections (hog-wallow uplands of Mississippi). The stiff and unmanageable character of this kind of soil stands in the way of its successful cultivation.

The third class of soils resulting from the intermixtures of the two classes just mentioned, exhibit all the grades between the brown loams of the uplands and the stiff beeswax soils above described. Upon these mixed soils the post-oak is a characteristic growth, and the post-oak lands of this division are, in general, like those of the Rotten Limestone, which are formed in a similar way.

The surface loam is here, as elsewhere, more or less deeply tinged with iron, and in some places the color becomes a dark-red, and both soil and subsoil are filled with concretionary pebbles of brown iron ore. These are known in Alabama as the red gravelly lands, and are similar to the "Buncombes" of Pontotoc ridge, in Mississippi. In both States they are distinctly connected with calcareous strata. While these soils are fertile, they are not so desirable as other varieties, since the pebbles dull the plow and the lands are very liable to injury from washing. As yet no analyses have been made of any of these mixed soils, or of the bald hill-top prairies or beeswax lands, so that we can speak only in generalities concerning them.

BLUE-MARL LANDS.

These lands, which are underlaid by a bluish micaceous marl, are for the most part, covered with beds of sand, loam and pebbles of a later age, and it is only along the drainage slopes of certain streams flowing into the Chattahoochee river that the marls are concerned in the formation of the soils. The area over which their influence is felt in the soil is a limited one, and even within this area there are many varieties. It is thus somewhat difficult to fix upon an estimate of the area here included, but it is put provisionally at 550 square miles.

As already stated, the greater part of the territory of the blue-marl is covered with later deposits, and bears, therefore, the characters of the brown-loam uplands, and of the pine hills, according to the nature of the surface beds. Along the Cowikee and Bear creeks and their tributaries, however, these surface beds have in great measure been removed, and the blue marl and the stratum of joint clay, with which it is interbedded, are exposed. These materials, mixed with the loam from the higher levels, together form the well-known Cowikee lands. Throughout the region the comparatively level clayey or marly lands alternate with ridges capped with a highly micaceous sandy loam. The ridges, as before stated, are sandy, and are timbered with post and black-jack oaks and long-leaf pine; but where the soil becomes more loamy, the pines diminish in numbers, and the other species of oaks replace partly or entirely the black-jack.

On each side of the Cowikee and Bear creeks the lands are stiffer, from an admixture of the clay above mentioned, and more productive, because of the presence of lime. On these creeks there are level or gently undulating tracts with a clayey soil, forming a kind of prairie, in which, strange to see, the long-leaf pine is a prominent tree, associated with hickory, white and Spanish oaks, and, in the lower places, with sweet and sour gums and maple, all covered with long moss. In many places the stiff clay subsoil is filled with white concretions of lime, derived probably from the marl. In some of these localities the short-leaf pine replaces the

long-leaf species. It is thought by some that the lands on the north side of the creeks are lighter and less charged with lime than those on the south side, and there is a corresponding difference in the growth of the cotton, which on the north side is smaller and more liable to rust after a few years' cultivation of the soil. In the so-called Cowikee lands of this region there are patches of hog-wallow clay, a stiff intractable substance.

The lowlands in this region are inhabited mostly by the blacks, by whom they are cultivated, since the white people suffer from malarial fevers. One analysis has been made of the soils of this region.

No. 96. *Bottom or low-ground soil*, Cowikee lands, north of Clayton, Barbour county. Depth, eight inches; vegetation, red, white and post-oaks, hickory and short-leaf pine; color, brown, changing into light yellowish gray subsoil.

LOW-GROUNDS SOIL, COWIKEE LANDS, BARBOUR COUNTY.

	No. 96.	
Insoluble matter	73.303	84.895
Soluble silica	11.592	
Potash		0.245
Soda		0.060
Lime		0.280
Magnesia		0.351
Brown oxide of manganese		0.113
Peroxide of iron		2.666
Alumina		5.489
Phosphoric acid		0.113
Sulphuric acid		0.013
Water and organic matter		4.708
Total		98.933
Hygroscopic moisture		5.544
absorbed at	5.6 C.°	

As has been said, the Cowikee lands are considered the best cotton lands in the section in which they occur. The analyses shows a fair proportion of potash and phosphoric acid, with a large percentage of lime, by which these are put in an available condition. From the large amount of siliceous matter this soil is easily tilled. The statistical map shows that about 20 per cent. of the whole area formed by these soils is cultivated in cotton.

POST-OAK FLATWOODS REGION.

This region occupies a narrow belt extending from the Mississippi line through the lower part of Sumter and the middle of Marengo to the Alabama river, in the vicinity of Clifton, in Wilcox county, and embraces an area which is approximately 335 square miles.

The flatwoods of post oaks have an average width of perhaps three to five miles, and a nearly level or gently undulating surface. They are bordered on the northern edge by the hilly prairie region just described, and on the southern by the hills of brown loam, or oak and pine region. The hills of the latter rise to a height of 200 feet above the general level of the flatwoods. These hills encroach upon the flatwoods in some places and recede from them in others, so that the width of the belt is quite variable. The hills are capped with the sand and other beds of the drift, but the laminated clays, which form the substratum of the flatwoods, are to be seen at the bases of most of them, and for several miles the hills have much the same characters as the flatwoods themselves, and might perhaps with propriety be included in this division.

The formation upon which the flatwoods and the adjoining hills are based is a heavy, dark-gray laminated clay belonging to the lower or lignitic division of the Tertiary. The flatwoods soil proper is the result of the disintegration of this clay. When wet by the rains, this clay becomes a tenacious, grayish, sticky mass, specked with red, which is in texture much like some of the clay of the prairie hills, but, unlike that, is rather deficient in lime.

The prevailing tree throughout the flatwoods is the post oak, of long, lank habit, but the short-leaf pine, and in places also the black-jack, are associated with it. The post-oak soils are tolerably well suited to the cotton-plant, which grows upon them to the height of three or four feet, and yields from 600 to 800 pounds of seed cotton to the acre when the land is fresh. From their texture these soils are generally difficult to cultivate. There seems to be no subsoil, properly speaking, at least none differing essentially

from the soil, which continues, without material change, to a depth of ten or fifteen feet, and passes gradually into the dark-gray laminated clay above spoken of. Two analyses of the flatwoods soils or clays and one of a subsoil have been made.

No. 25. *Post-oak Flatwoods soil*, four miles west of Livingston, Sumter county, collected by Dr. R. D. Webb. Depth, ten inches; vegetation, chiefly post-oak, with some red oak, hickory, and short-leaf pine; color, gray, flecked with red.

No. 26. Subsoil of the above. Depth, ten inches to four feet; color, also like the preceding.

No. 98. *Post-oak and Flatwoods clay*, six miles south of Linden, Marengo county. Depth, ten inches; vegetation, chiefly post oaks; color, reddish-yellow, spotted.

FLATWOODS SOILS AND SUBSOILS.

	SUMTER COUNTY.				MARENGO CO.	
	Soil.		Subsoil.		Clay.	
	No. 25.		No. 26.		No. 98.	
Insoluble matter	67.020	77.070	79 662	84.693	72.746	81.673
Soluble silica	10.050		5.031		8.926	
Potash	0.295		0.223		0.416	
Soda	0.125		0.059		0.112	
Lime	0.198		0.359		0.080	
Magnesia	0.610		0.596		0.691	
Brown oxide of manganese	0.115		0.073		0.106	
Peroxide of iron	6.543		7.711		12.406	
Alumina	10.198		3.308		2.473	
Phosphoric acid	0.212		0.072		0.103	
Sulphuric acid	0.027		0.026		0.061	
Water and organic matter	5.031		2.356		1.906	
Total	100.424		99.476		100.026	
Hygroscopic moisture	13.040		12.841		13.941	
absorbed at	28 C.[a]		9. C.[a]		8 C.[a]	

Of the three analyses above given, No. 98 is perhaps the most characteristic; the others come from near the vicinity of the prairie region, and hence, especially the subsoil No. 26, have rather larger percentages of lime. The potash and phosphoric acid in the others are sufficient in quantity; lime is inadequate, but the large percentage of magnesia shown by all is noteworthy. The same may be noticed in

the Mississippi flatwoods soils, and it seems to be characteristic. They are all deficient in vegetable matter, which appears to be a capital defect in all the flatwoods soils analyzed. The addition of lime and the plowing under of green crops and deep cultivation are at once suggested as a means of improvement of these soils, thorough drainage being first of all necessary.

THE LIME-HILLS OR LOWER-PRAIRIE REGION.

This agricultural division embraces portions of Choctaw, Washington, Clarke, Monroe, Conecuh, Covington, Crenshaw, and Geneva counties, and occupies a belt which varies greatly in width, as may be seen by referring to the map. In the first-named four counties these prairie spots are more nearly continuous; in the others they appear, only in detached bodies, often far apart. The area is put at 1,250 square miles.

GENERAL CHARACTERS.—From a geological point of view this subdivision includes that part of the State in which the calcareous portions of the Tertiary formation (especially the upper part of the Claiborne and the whole of the Jackson groups) lie at or near the surface. Over much of this territory the white limestone of the Vicksburg group is a conspicuous rock, but it extends also southward far beyond the limits above given, without producing limy or prairie soils. (*a*) The greater part of this area has the characters of the brown-loam uplands or of the pine hills, and it is only in the first and second bottom and on the summits of the lower hills that the limy soils are to any extent encountered. The prairie or limy spots are interspersed in such a manner among the brown-loam and sandy pine lands that nothing short of a detailed map could show their actual occurrence. The tint on the map is therefore intended to show only the limits between which this kind of soil occurs at all.

a In the sequel the term "white limestone" is usually made to include both the white or grayish impure limestone of the Jackson group and the commonly purer orbitoidal limestone of the Vicksburg group. This use of the term is fully justified by the practice of the country where these rocks occur.

Unlike the prairie region of the Cretaceous, there is in this region comparatively little level land, except upon some of the broader table-lands with brown-loam soils. These table-lands break off toward the water-courses in a series of hills, which are capped with pebbles and sand, and which are clothed with a growth of long-leaf pine and black-jack oak. Upon the table-lands the growth is long and short-leaf pine and the usual variety of upland oaks.

The lower hills, as before stated, have here and there the peculiar black calcareous soil which gives the name to this region, and this soil extends usually to the bottom lands below, where it is, however, mostly tempered with the sandy washings from the uplands. The black prairie soils are generally quite fertile, and most of the hillsides, usually very steep where it occurs, are cleared and under cultivation. In its general features the country made by these rocks is very similar to the hill-prairie region of the Cretaceous.

In Choctaw and Washington counties, near the line of Mississippi, the lime-hills, or rather the prairie lands, are characteristic and numerous, occupying occasionally moderately level tracts of 100 acres or more. Toward the east, however, they diminish in frequency and continuous extent, and are seen no farther east than the lower part of Crenshaw county, except a small tract in the adjoining lower corners of Geneva and Henry; but long before this limit is reached the country bears almost exclusively the characters of the long-leaf pine hills, the limy soils being in small, detached bodies.

Soils.—The rock which gives rise to the peculiar soils of this division is an impure argillaceous limestone or calcareous clay stone, bearing often a considerable resemblance to the Rotten Limestone of the Cretaceous formation, as may be seen by reference to the subjoined analysis.

No. 137. *Impure argillaceous limestone* (Jackson), overlying the shell stratum at Claiborne, Monroe county.

In disintegrating the rock it yields a waxy, gray calcareous clay soil, which becomes black when mixed with vegetable matter. This soil is stiff and difficult to cultivate, but is very productive, and is quite similar to some of the prairie soils of the upper prairie region.

A second soil variety is of loose texture and black color, often full of small rounded fragments of the limestone, some of which are very soft and crumble easily between the fingers. The solid limestone is usually at a considerable depth from the surface. This soil, which characterizes the shell prairies, is one of the best of this division, and rarely fails to yield excellent crops, either of corn or cotton, and when fresh will produce nearly a bale of the latter to the acre. Occasionally loose shells, set free by the decay of the rock, abound in the soil, and it is not uncommon to find masses of these shells agglomerated into a compact and hard rock.

A specimen of this variety of soil from Mr. Robert A. Long's, Sec. 9, T. 8, R. 3 W., in Washington county, was analyzed with the following result:

No. 139. *Loose black-shell prairie soil*, Washington county. Depth, eight inches; vegetation, dogwood, white and black oaks, sweet gum, ash, short-leaf pine, yellow wood, and buckeye bushes. The soil is loose, black, and full of soft crumbling fragments of limestone.

IMPURE ARGILLACEOUS LIMESTONE, AND LOOSE BLACK SOIL OF THE LIME-HILLS.

	MONROE COUNTY.	WASHINGTON COUNTY.
	Impure argillaceous limestone.	Loose black soil.
	No. 137.	No. 139
Insoluble matter	28.394	21.655
Soluble silica	2.920 } 31.314	1.754 } 23.409
Potash	0.502	0.553
Soda	0.077	0.192
Lime	34.952	29.195
Magnesia	0.743	0.489
Brown oxide of manganese	0.156	0.113
Peroxide of iron	1.798	5.421
Alumina	1.159	5.155
Phosphoric acid	0.096	0.371
Sulphuric acid	0.290	0.462
Carbonic acid	27.471	22.177
Water and organic matter	2.207	12.845
Total	100.765	100.382
Hygroscopic moisture absorbed at	.....	13.56 20.5 C.°

A comparison of the above with the specimen of limestone will show that this soil is hardly anything more than the disintegrated limestone enriched with vegetable matter. The potash and phosphoric acid are much above the average, and the great fertility of this class of soil is easily understood. The large proportion of sulphuric acid suggests the presence of gypsum, which is not uncommon in very many of the soils and clays of this region.

A third variety of soil common in this region is a mixed one, resulting from the reaction of the limestone upon the red loam, which in places overspreads it. This is a stiff, waxy, reddish or chocolate-colored clayey material, difficult of cultivation, but fertile, and in most respects similar to the post-oak prairie soil of the upper prairie region, which it resembles not only in its mode of formation, but also in its timber, which is mostly post oak, associated with some short-leaf pine, hickory, sweet gum, and dogwood, all draped with long moss. The analysis given (No. 91) will show approximately the composition of the red-mixed soil.

A large proportion of the soils throughout this region, as has already been stated, are derived from the superficial beds of drift origin. The analyses given below will show their general character.

No. 90. *Upland brown-loam soil*, six miles north of Gosport, Clarke county. Depth, 10 inches; vegetation, post, red, and Spanish oaks, short and long-leaf pine, and some hickory; color, brown.

No. 91. *Underclay subsoil of No.* 90. Depth, 24 to 36 inches; vegetation, as above; color, yellowish-red.

The washings from the uplands often produce a lastingly productive soil, and this variety is common along the creeks of Conecuh county, especially Murder, Bottle, and the tributaries of the former.

Nos. 89. *Murder Creek second-bottom soil*, two miles west of Evergreen, Conecuh county. Depth, 12 inches; vegetation, sweet gum, magnolia, white and water oaks, shoat-leaf and spruce pines; color, brownish-red.

BROWN-LOAM SOILS AND UNDERCLAY OF LIME-HILL REGION.

	CLARKE COUNTY.		CONECUH CO.
	Upland brown-loam Soil.	Underclay Sub-Soil.	Murder Creek Second-bottom Soil.
	No. 90.	No. 91.	No. 89.
Insoluble matter	87.753	71.652	89.870
Soluble silica	3.087	5.962	1.592
	90.840	77.614	91.462
Potash	0.140	0.350	0.140
Soda	0.010	0.048	0.016
Lime	0.096	0.326	0.094
Magnesia	0.066	0.091	0.018
Brown oxide of manganese	0.050	0.133	0.078
Peroxide of iron	1·999	7.408	2.385
Alumina	3.397	8.606	0.355
Phosphoric acid	0.120	0.295	0.122
Sulphuric acid	0.010	0.080	0.005
Water and organic matter	3.080	5.187	2.480
Total	99.808	100.138	100.155
Hygroscopic moisture	2.895	14.380	2.653
absorbed at	23 C.°	22 C.°	24 C.°

Nos. 90 and 89 are light loam soils of very fair quality, quite similar to each other, and are not materially different from the soils of the pine lands and oak and pine uplands, which may be consulted in this connection. No. 91, however, comes from a hillside below the level at which 90 was taken, where the sandy surface loam had been removed by washing rains, and in it we see the material which forms the soil of the lime-hills. Under cultivation this would become a black-prairie soil of great fertility. While it is not strictly a soil (having been taken from a wash several feet below the surface), the analysis gives us a fair idea of the character of the soils which give name to this region and of the material to which the deeper roots of cotton must often penetrate from the sandy surface.

THE LONG-LEAF PINE REGION.

In the region of the oak and pine uplands the sandy ridges are usually timbered with long-leaf pine, while the flat table-lands and some of the slopes and the second bottoms have the characteristic oak and hickory growth, with

which some short-leaf pine and occasionally long-leaf pine are associated. As we go southward in this region of mixed growth the long-leaf pine becomes more prevalent, and is found both on the table-lands and in the low grounds at first associated with the upland oaks, but farther south occupying the ground almost entirely in company with the black-jack, high-ground willow, and turkey oaks, and other trees, which are at home only upon the sandiest soils. At the same time the shrubby undergrowth gradually disappears almost entirely, and we are thus ushered into the open pine woods. Similarly with the topography, the hills of the preceding section gradually diminish in height and abruptness, and the country becomes undulating or rolling rather than hilly, and southward sinks away into the flat lands of the coast. The whole area of the long-leaf pine region, as thus limited, is about 7,790 square miles. The counties included are named below under the three subdivisions, which are in great measure based upon topographical characters. These subdivisions are:

The Long-leaf Pine Hills.

The Open, Rolling Pine Woods, with Lime-sinks.

The Pine Flats.

LONG-LEAF PINE HILLS.

In southeastern Mississippi the pine hills, which characterize the lower part of that State, flatten out eastward toward the Alabama line, thus forming a transition into our open, rolling pine woods. That part of Washington county to which the deep-green color of the pine hills has been given on the map does not differ essentially from that part which is designated as open pine woods, except in being more broken, and it is not necessary to give a separate account of its agricultural features, which are the same as those of the next succeeding division. The area of this pine hills or transition region, which is altogether in Washington county, is about 100 square miles.

ROLLING AND OPEN PINE-WOODS AND LIME-SINK REGION.

This region includes parts of the following counties: Washington, Mobile, Baldwin, Clarke, Monroe, Conecuh,

Escambia, Covington, Coffee, Geneva, Dale, and Henry, and embraces an area of 6,570 square miles.

The territory here included is underlaid throughout by the white or orbitoides limestone of the Upper Eocene or Vicksburg age. The limestone, however, is in great measure covered with the sands and loams of a later period. Where this rock lies above the drainage level (which is more particularly the case in the southeastern part of the State, where the influence of the elevation of the Florida peninsula is felt) it is pitted with caverns and traversed by underground passages. The falling-in of the roofs of such caverns causes sinks or depressions, which are sometimes filled with water, forming lakes and ponds, and the subterranean waters, flowing through the channels above mentioned, emerge as big springs. In the southwestern part of the State the limestone sinks gradually away below the drainage level, and its influence on the topography is comparatively slight.

The prevailing surface material throughout the whole region, being sandy and more or less loose and porous, quickly absorbs the waters falling upon it, and the formation of deep gullies has thus been prevented, and the face of the country is in general slightly rolling, with no great differences in elevation. In some places, especially within the drainage areas of the Chattahoochee and Alabama rivers and in the northern parts of this region, the admixture of red-clay loam with the sands brings about modifications both of the topography and of the soils, because of the varying degrees of resistance to denudation and the varying qualities of the admixtures of the two materials.

Upon the uplands throughout this region the prevailing growth is the long-leaf pine, associated with little or no undergrowth, but with black-jack, turkey, and high-ground willow oaks, and some hickories. Upon the sterile sandy ridges the growth is stunted, and scrubby oaks of several species are associated with the scrubby pines. The headwaters of the streams are found usually in slight depressions and swampy tracts, with a growth of magnolia, bay, gum, juniper, short-leaf pine, water oak, etc. The open swamps in the region have the richest and most varied her-

baceous flora, some characteristic species of which have been given on page 292, in the floral list prepared by Dr. Charles Mohr.

The absence of all underbrush in many of the pine forests enables one to see for great distances between the stright trunks of the pines, and over the rolling land thus unobstructed by undergrowth a wagon may be driven in any direction without following any beaten track. The pines shade the ground comparatively little, and a great variety of grasses and leguiminous plants flourish and give sustenance to herds of cattle and sheep. This region cannot be called a good farming country, though tolerably fair crops are raised in the more favored localities, such as low grounds. The raising of cattle gives support to many of the inhabitants, and the pines to many more, both in the lumber and the turpentine which they yield.

The prevailing soil of this region, as has already been said, is sandy, and of a gray or ash color. In the better spots the color is a dark gray. This is the soil of the better class of pine lands, and its composition may be seen from the subjoined analysis. With some assistance from fertilizers very fair crops of cotton and corn are produced.

No. 88. *Upland pine-woods soil*, 13 miles east of Andalusia, Covington county. Depth, 10 inches; vegetation, long-leaf pine, post, Spanish, black-jack, and high-ground willow oaks, with occasional small hickories; color, brownish-gray.

UPLAND PINE-WOODS SOIL, COVINGTON COUNTY.

	No. 88.	
Insoluble matter	90.815	92.390
Soluble silica	1.575	
Potash		0.170
Soda		0.036
Lime		0.085
Magnesia		0.032
Brown oxide of manganese		0.112
Peroxide of iron		1.143
Alumina		3.018
Phosphoric acid		0.111
Sulphuric acid		0.067
Water and organic matter		2.772
Total		99.936
Hygroscopic moisture		2.558
absorbed at	23.° C.	

This, considering the large proportion of insoluble matter, is a fairly good soil, though it is deficient in lime and magnesia. It resembles in composition many of the soils of Florida.

In places, especially along the drainage slopes of the Alabama and Chattahoochee rivers, the red loam occurs as substratum to the soils and subsoils, and frequently, by denudation, comes to form the surface. In this way quite a variety of soils is produced, but they do not differ from similar soils of the brown-loam uplands, which result from the same admixtures. Occasionally the underlying limestone in its disintegration is mingled with the surface loam, and there results then a red limy soil of great fertility, similar to that of the red-lime lands of Jackson county, Florida. The best known tract of this kind of soil occurs along the Chipola river in Florida, and its northern extremity reaches up into the eastern part of Geneva and adjoining part of Henry county, Alabama. Of a similar nature are the red limy soils of the lowlands of Murder and Bottle creeks, in Conecuh county, which have been spoken of before in connection with the lime-hills region, to which they are contiguous.

The bottom lands of this region have, as a rule, light sandy but productive soils, which vary in quality with those of the uplands adjoining. The usual growth in the bottom lands consists of magnolia, bay, ti-ti, sweet-leaf, juniper, star anise, laurel, sweet shrub, etc.

THE PINE FLATS.

Toward the Gulf coast the rolling pine lands sink away into low pine barrens, in which the tree-growth consists of the long-leaf pine and the so-called Cuban pine, and with these a smaller growth of several species of ilex, etc. The low, wet margins of ponds support a varied and beautiful herbaceous growth, consisting of *Sarracenias*, *droseras*, *Catesby's lily*, and a number of others mentioned in the list of plants. The soil here is sandy and sour, little suited to cultivation, and cotton is not planted. The settlements are mostly confined to the vicinity of the streams.

The coast plain and the islands off the coast have generally a soil of drifting sands, destitute of timber, but supporting a few characteristic shrubs and lesser plants. The pine flats are limited to the lower parts of Mobile and Baldwin counties as a body, but low pine barrens of very similar nature are seen further inland. The area is put at 1,120 square miles.

ALLUVIAL REGION.

This includes the alluvial region of Mobile river and the saline marshes of the coast, and embraces parts of Washington, Mobile and Baldwin counties, comprising an area of some 130 square miles.

ALLUVIUM OF MOBILE RIVER.

Below the junction of the Alabama and Tombigbee rivers, the waters of these streams reach the bay of Mobile by several channels, the principal of which is the Mobile river, but the Tensas and Middle rivers and others diverge from the main stream, and form a kind of delta region, low, flat, and subject to overflow, generally covered with a growth of cypress. Near the bay this swamp assumes the character rather of a marsh, in which the courses of the streams are often nearly indistinguishable. These swamps are uncultivated, and have in drier spots, besides the cypress, tupelo gum and several species of poplar, elms, palmetto, etc.

SALINE MARSHES OF THE COAST.

These are only found in the counties of Mobile and Baldwin. They are without timber, but have a herbaceous growth chiefly of rushes and sedges, which is characteristic. These plants are enumerated in the list referred to. The muck of decayed vegetable matter from the marshes may often be applied with profit to the sandy soils which adjoin them, and the marshes themselves in other States have sometimes been reclaimed for cultivation. The area of sea-marsh in Alabama, on account of comparatively limited extent of coast, is necessarily small, and few, if any, attempts have been made toward reclamation.

LIST OF TREES AND PLANTS CHARACTERISTIC OF EACH REGION OF THE STATE.

The following is a list, with botanical and common names, of some of the most important and characteristic trees and lesser plants of the various agricultural regions of the State, prepared by Dr. Charles Mohr, of Mobile:

I. *Lower Pine Region, or Coast Pine Belt*, including—

a. The maritime plan, with saline marshes and flats, and dunes of drifting sands on the islands near the coast and on the sea-shore: Shrubs and trees—*Quercus virens* (live oak), var. *maritima* and *Q. Phellos* (willow oak), var. *arenaria Quercus virens* being the typical form on the inlets and bayous with higher banks and a more retentive soil; *Vitis incisa, bacharis halimifolia, Lycium Carolinianum, Yucca aloifolia.* Herbs—*Chenopodium Boscianum, Chenopodina maritima, Salsola Kali, Sesuvium portulacastrum, Batatas maritima, Ipomœa Pes-Caprœ, Cyperus Le Contei, Uniola paniculata, Panicum repens.* In the saline or brackish marshes: *Baccharis halimifolia, Myrica cerifera* (candleberry), *Fimbristylis spadicea*, var. *castanea; Juncus Rœmerianus, Triglochin triandrum, Scirpus maritimus* (rush), *S. pungens, Brizopyrm spicatum, Statice Caroliniana, Gerardia maritima, Borrichia frutescens, Ipomœa sagittifolia, Batis maritima, Salicornia ambigua* (samphire), *Cakile œqualis.*

b. Open, grassy river swamps and wooded alluvial bottoms, more or less inundated: Open river swamps—*Zizania aquatica* (wild rice), *Scirpus lacustris* (round rush), *Phragmites communis* (reed), *Panicum virgatum.* Sedges—*Rhynchospora*, several species; *Claudium, Carex riparia, Cyperus stenolepis, C. Michauxianus, C. articulatus, C. haspan, C. virens*, several species of *Sagittaria* (arrow-head), *Cicuta maculata* (water hemlock), *Cacalia lanceolata, Gerardia purpurea*, var. *fasiculatas; Aster flexuosus, A. divaricatus, Solidago sempervirens* (golden rod), *S. lanceolata, Hibiscus Moscheutos, Kosteletzkya Virginica, Lythrum lineare.* Shrubs—*Persea Caroliniana*, var. *palustris* (red bay); *Myrica cerifera, Salix nigra, Baccharis halimifolia.* Trees (forest swamps)—*Taxodium*

distichum, the variety yielding the red cypress lumber; *Nyssa uniflora*, or tupelo gum; *Populus heterophylla*, *P. monilifera* (cotton-wood), *Fraxinus viridis* (ash), *F. platycarpa*, *Persea palustris*, *Carya aquatica* (hickory); *Quercus aquatica* (water-oak), *Ulmus alata* (wahoo), *U. Americana* (elm), *Catalpa bignonioides*, *Sabal Adansonii* (dwarf palmetto), *Ilex opaca* (holly), *I. decidua*.

c. Low flat pine barrens, or pine meadows: *Pinus cubensis* (*P. Elliottii*, pine-pitch), *P. australis* (long-leaf pine), *Ilex glabra* (gallberry), *I. Cassine* (yaupon), *Sarracenia* (pitcher-plants) of several species, *Drosera filiformis*, *D. brevifolia* (sundews), *Dichromena leucocephala* (white star-grass), *Eriocaulon*, several species (pipeworts), *Lachnanthes tinctoria*, *Aletris aurea* and *A. farinosa*, *Sabbatia gracilis* and *S. gentianoides* (American centaury), *Tofieldia pubens*, *Lilium Catesbæi*, *Zygadenus glaberrimus*, *Rhynchospora* in numerous species, largely prevailing with *Scleria oligantha*, *S. Elliottii*, and *S. Michauxii*; *Aristida spicata*, *Ctenium Americanum*, *Paspalum racemulosum* and *P. purpurascens*, *Panicum verrucosum*, *P. microcarpon*, and *P. ignoratum*; *Andropogon tener*, *A. Virginicus*, *A. macrourus*, and *A. scoparius* (broom-sedge); *Erianthus alopecuroides*, *Gratiola pilosa*, *Pinguicula lutea*, *Chaptalia tomentosa*, *Bartonia verna*, *Leptopoda fimbriata* and *L. brevifolia*, *Helianthus heterophyllus*, *Bigelovia nudata*, *Erigeron vernum*, several species of *Eupatorium*, *Aster dumosus*, *Liatris odoratissima* (vanilla plant), *L. graminifolia*, and *L. spicata*; *Carphephorus Pseudo-Liatris*, several species of *Ludwigia*, *Polygala ramosa*, *P. cymosa*, *P. cruciata*, *P. Chapmanii*, and *P. Hookerii*; *Linum rigidum*, *Hibiscus aculeatus*, *Hypericum cistifolium*, *H. myrtifolium*, and *H. fasciculatum*.

d. The evergreen glades of the hummock lands and wooded bottoms, more or less sphagnous, with the open swamp bordering upon them: Trees and shrubs—*Magnolia grandiflora* (bull bay), *M. glauca* (bay), *Persea Caroliniana* and its variety *palustris*, *Nyssa Caroliniana*, *Cliftonia ligustrina* (the ti-ti), *Olea Americana*, *Tymplocos tinctoria* (sweet-leaf), *Calycanthus lævigatus* (sweet shrub), *Myrica inodora*, *Cupressus thyoides*, or juniper, *Pinus Elliottii*, *P. Tæda* (lob-lolly pine), *Quercus aquatica* (water oak), *Oxydendrum arboreum*, or sour-wood, *Zanthoxylum Clava-Herculis* (prickly

ash), *Illicium Floridanum* (star anise), *Ilex coriacea, I. Cassine* (paupon), *I. ambigua, I. Dahoon, Rhus venenata* (poison elder), *Vaccinium virgatum* and *V. myrsinites* (huckleberries), *Halesia diptera* (snow-drop tree), *Cyrilla recemiflora, Bumelia lanuginosa.* In the open swamps: *Sarracenia rubra, S. flava, S. Drummondii, S. Psittacina* (pitcher-plants), *Sabbatia macrophylla, Asclepias paupercula* (marsh milkweed), *Tiedemannia teretifolia, Lophiola aurea, Calopogon pulchellus, Pogonia* (several species), *Xyris,* and most of the plants mentioned above as inhabiting the bogs of the pine meadows; *Rhynchospora* (several species), *Paspalum præcox, Panicum gibbum, P. Curtisii, P. virgatum,* and *P. proliferum, Rotbœllia rugosa.* As taking possession of the waste lands, or the cultivated soils, the following are to be mentioned: *Cyperus rotundus* (nut-grass), *C. repens, C. Baldwinii, Panicum sanguimale,* or crab-grass, *Cynodon Dactylon* (Bermuda grass), several troublesome bind-weeds, such as *Ipomœa commutata* and *I. lacunosa* (morning-glory), *Sesbania macrocarpa* and *vesicaria.*

e. The rolling pine lands, covered with forests of *Pinus australis,* and almost devoid of undergrowth: *Quercus cinerea* (narrow-leaf black-jack or high-ground willow oak), *Q. nigra* (broad-leaf black-jack, or simply black-jack), *Q. Catesbœi* (fork-leaf black-jack, turkey oak), *Carya tomentosa* (mockernut hickory), *Ceratiola ericoides, Sabal serrulata* (saw palmetto), *Asimina parviflora* (dwarf papaw), *Zucca flamentosa* (bear-grass), several species of *Rhynchospora* preferring a sandy, dry soil, such as *R. Grayii, R. compressa,* etc. Of grasses: *Danthonia sericea, Aristida lanata, Sporobolus junceus, Eatonia filiformis, Paspalum racemulosum, P. Floridanum, Panicum rufum, P. depauperatum* and *P. dichotomum,* in varieties; *Andropogon Elliottii and A. scoparius* (broom-sedge), *Sorghum nutans, Brewería humistrata, Rhynchosia tomentosa* in all its varieties, *R. galactioides, Lupinus diffusus* and *L. villosus, Galactia sessiflora, Rhexia glabella* (deer-tongue), *Chrysobalanus, oblongifolius, Apium divaricatum, Tetragonotheca helianthoides Vernonia angustifolia* (iron-weed), *Sericocarpus tortifolius, Liatris elegans, L. squarrosa* (rattlesnakes' master), *Helianthus radula Coreopsis senifolia, Aster adnatus* and *A. patens, Gaillardia lanceolata, Eupatorium aromaticum, Asclepias Michauxii* and *A. amplexicaulis* (milk-

weeds), *Sabbatia brachiata* (centaury), *Gerardia Plukenetii, G. Skinneriana, Ruellia ciliosa, Kalmia hirsuta, Buchnera elongata.*

Among the weeds of the fields and gardens are prominent *Richardsonia scabra*, or Mexican or Florida clover, *Cassia nictitans, Polypremum procumbens, Ambrosia artemisiæfolia* (hogweed), and *Erigeron Philadelphicum* (rag-weed), *Panicum sanguinale* (crab-grass).

II. *Region of mixed tree growth, or upper pine region,* including—

a The lowland, with its heavily-wooded river valleys and creek bottoms. Predominating trees: *Pinus australis, P. glabra* (spruce pine), *P. Tæda, Cupressus thyoides* (white cedar), *Quercus Michauxii,* Nutt. (swamp chestnut oak, *Q. Prinus bicolor* of Michx.), *Q. lyrata* (overcup oak), *Q. alba* (white oak), *Q. falcata* (Spanish oak), *Q. rubra* (red oak), *Q. aquatica* (water oak), *Carya alba* (shell-bark hickory), *C. tomentosa* (mockernut), *C. abuatica* (water bitternut), *C. porcina* (pig nut), *Celtis Mississippiennsis* (hackberry), *Planera aquatica, Platanus occidentalis* (sycamore), *Ulmus Americana* and *U. alata, Persea Caroliniana, Fraxinus Americana* (white ash), *Acer rubrum* (red or swamp maple), *Negundo aceroides* (ash-leaf maple), *Prunus Americana* (red plum), *Tilia Americana* (basswood, linden), *Liquidambar styraciflua* (sweet gum), *Gleditschia triacunthus* (honey-locust), *Ilex opaca* (holly), *Magnolia grandiflora, M. acuminata, M. macrophylla* (large-leaf bay), *M. Fraseri* (umbrella trees, cucumber trees), *Bumelia lycioides, Rhamnus Caroliniana* (buckthorn), *Cratægus spathulata, C. apiifolia,* and *C. aestivalis* (haws), *Illicium Floridanum* (star anise), *and Catalpa bignonioides.*

b. Uplands and so-called wooded prairies or post-oak flatwoods: *Quercus tinctoria* (black-oak), *Q. obtusiloba* (post oak), *Q. nigra* (black-jack), *Q. falcata* (Spanish oak), *Q. rubra* (red oak), *Carya tomentosa, C. amara* (bitternut), *C. porcina, Ostrya Virginica* (hop hornbean), *Castanea pumila* (chincapin), *Æsculus parviflora* (buckeye), *Thalictrum anemenoides,* var. *debile, Hepatica triloba* (liver leaf), *Ranunculus abortivus, Zanthorhiza apiifolia* (yellow root), *Calycocarpum Lyonii, Viola pedata,* var. *bicolor, Hypericum galioides* (in swamps), *Stellaria*

pubera, *Silene Virginica*, *Sida Elliottii*, *Habenaria tridentata*, *Geranium maculatum*, *Hydrangea arborescens*, *H. quercifolia* (seven bark), *Philadephus grandiflorus*, *Stokesia cyanea*, *Callirrhœ Papaver*, *Calamintha Caroliniana*, *Onosmodium Virginianum* and *O. Carolinianum*, *Phaceliapusilla*, *Phlox paniculata*, *Subbattia chloroides*, *Acerates paniculata*, *Aristolochia tomentosa* (tobacco-pipe), and *Gonolobus hirsutus*. Many of the grasses which are common in the region below occur also here: *Uniola latifolia*, *Bromus ciliatus*, *Arrhenatherum avenaceum*, *Poa flexuosa*. As weeds, besides those above mentioned, the following are common: *Xanthium strumarium* (cocklebur), *Bidens bipinata* (Spanish needles), *Polygonum*, several species (smartweed), all growing in low rich spots; *Amarantus chlorostachys*, *A. hybridus*, and *A. spinosus* (careless weeds), *Portulaca oberacea* (purslane), *Lepidium Virginicum* (pepper cress) *Specularia perfoliata*, several species of *Cerastium* and *Stellaria* (chickweeds), *Maruta Cotula* (dog fennel), *Helenium augustifolium* (bitter-weed), and several species of *Rubus* (blackberry or bramble).

III. *The Cretaceous plain*, with the so-called bald and wooded prairies of the black belt.

The growth is mostly the same as that of the division adjoining it below. *Quercus Phellos* is here found more frequently and in its best devlopment.

This region is bounded on the north by the interior long-leaf pine region of the central drift belt. Many of the trees and shrubs, such as *Illicium Floridanum* and *Magnolia grandiflora*, occur here, finding their northern limit. The flora of the prairies is similar to that of the grassy plains of the northwestern States east of the Mississippi, with coarse *Silphium*, or rosin-weed (*S. laciniatum*, and *S. lævigatum*), *Rudbeckia triloba*, late *Helianthi* (sunflowers), such as *H. atrorubens*, *H. mollis*, *H. tomentosus*, with others; *Lepachis pinnata*, *Petalostemon candidum*, and *P. carneum*; *Schrankia uncinnata*, *Desmanthus brachylobus*, in swamps; *Brunnichia cirrhosa*, *Hibiscus incanus*, *Cacalia ovata*, in copses and wooded banks; *Pycnanthemum linifolium*, *Penstemon digitalis*. Of shrubs, *Prunus umbellata*. Among the grasses *Paspalum distichum* and the crab-grass (*Panicum sanguinale*) are trouble-

some weeds in the cotton-fields of the black lands; also the various species of *Cassia—occidentalis, obtusifolia* and *Marilandica.*

IV.—*The Mountain region of North Alabama* to the valley of the Tennessee river, including the oak forests of the metamorphic region. In these *Quercus rubra, Q. tinctoria,* and *Q. falcata* greatly predominate.

On the high lands or extensive table-lands of the Carboniferous sandstone the following trees are found: *Pinus australis* (in patches), *P. mitis* (short-leaf pine), *P. Tæda* (loblolly pine), *P. inops* (here called mountain pine), *Quercus coccinea* (scarlet oak), *Q. Prinus,* (the mountain or tan-bark oak), *Q. Muhlenbergii, Q. nigra, Q. rubra, Q. obtusiloba,* with *Castanea vesca,* var. *Americana* (the chestnut), more or less stunted hickories and poplars, and the very common *Oxydendrum arboreum, Azalea nudiflora* in several forms, *Magnolia acuminata* and *M. cordata,* the butternut (*Juglans cinerea*), *Magnolia umbrella,* and *M. macrophylla* take to the richer slopes and valleys, along with *Tilia heterophylla* and *T. Americana* (the basswoods or lindens), *Ulmus fulva* (slippery elm), poplar (*Liriodendron*), black walnut (*Juglans nigra*), and *Ilex mollis.*

Herbs and shrubs: *Delphinium azureum* and *D. uncinatum, Sanguinaria Canadensis* (blood-root), *Dentaria* (several species), *Thalictrum dioicum, T. clavatum, Viola blanda, V. canina,* var. *sylvestris, V. pubescens, Hypericum aureum, Arenaria patula, Silene regia, Polygala Boykinii, Rosa lucida* (wild rose), *Pyrus coronaria* (crab-apple), *Calycanthus floridus* (sweet shrub), *Neviusia Alabamensis, Croton Alabamensis, Sedum Nevii, S. pulchellum, Heuchera Americana* (alum-root), *Saxifraga Virginiensis, Tiarella cordifolia, Hydrangea radiata, Sericocarpus conizoides, Aster Shortii, Solidago Curtisii* and *S. amplexicaulis, Silphium compositum, Parthenium integrifolium, Rudbeckia mollis, Phacelia bipinnatifida, Phlox divaricata, Silene, rotundifolia,* and *Campanula divaricata.*

Upon the limestone belts of the valleys and the slopes bordering on them are found groves of red cedar (*Juniperus Virginiana*), and on deep rich soils large poplars (*Liriodendron*), black walnut, ash, and white oaks. In the basin of

the Tennessee river are found, of forest trees, all those of a more northern range mentioned before, together with shrubs or small trees like the *Æsculus glabra* and *flava*, *Fraxinus quadrangulata*, *Rhus cotinoides*, and *Forestiera acuminata*. Black walnut, poplars, white hickory, and white ash are most frequent.

REMARKS ON COTTON PRODUCTION IN ALABAMA.

[The weight of the bale, as used in this report and in the tables, is 475 pounds, and in all the discussions and comparisons the proportion of lint or fiber to seed-cotton is assumed to be as 1 to 3.]

In total production in the United States Alabama stands No. 4, being below Mississippi, Georgia, and Texas; and in product per square mile Alabama also occupies the fourth place, producing 13.3 bales to the square mile, below Mississippi with 20.7 bales, South Carolina with 17, and Georgia with 13.8.

Some of the most prominent facts connected with the production of cotton in Alabama are set forth in the results of the enumeration presented in tabular form below. From these tables certain inferences may be drawn which are of interest, as showing where the cotton is produced, by whom, and what effect the continuous cultivation of cotton has upon the fertility of the soil.

TABLE III.—SHOWING POPULATION AND COTTON PRODUCTION IN EACH AGRICULTURAL REGION OF THE STATE.

	Area in sqare miles.	POPULATION.			COTTON PRODUCTION.									
							Av'ge per acre.				Total in tons			
		Total.	White.	Color'd	Acres.	Bales.	Fraction of bale (475 pounds.)	Seed-cotton.	Lint.	Seed.	Lint.	Seed.	Percentage of State's total production.	Cotton acreage per square mile.	Bales per square mile.
Total	51,540	1,262,505	662,185	600,320	2,330,086	699,654	0.30	429	143	286	166,168	332,336	100	45	14
Metamorphic region	4,460	129,705	85,072	44,633	236,745	71,285	0.30	429	143	286	16,930	33,860	10	53	16
Coosa Valley region	3,930	109,155	78,345	30,977	131,505	52,699	0.40	570	190	380	12,516	25,032	8	33	13
Coal Measures region	5,070	85,988	77,032	8,956	62,863	21,692	0.35	498	162	332	5,152	10,304	3	12	4
Tennessee Valley region	5,760	168,502	107,157	61,345	260,861	84,447	0.32	456	156	304	20,056	40,112	12	45	15
Oak and hickory uplands, with short-leaf pine	3,060	53,120	36,813	16,307	87,496	28,806	0.33	471	157	314	6,841	13,682	4	29	9
Gravelly Hills, with Long-leaf Pine	3,990	75,847	42,898	32,949	122,587	37,229	0.30	429	143	286	8,842	17,684	5	31	9
Central Prairie region	9,220	376,061	87,877	288,184	1,014,606	278,508	0.27	385	128	256	66,146	132,292	40	110	30
Oak and hickory uplands, with long-leaf pine.	9,470	186,633	99,371	87,262	399,357	120,739	0.30	429	144	286	28,676	57,352	17	42	13
Long-leaf Pine region	6,580	77,494	47,707	29,707	14,066	4,249	0.30	429	143	286	1,009	2,018	1	5	1

TABLE IV.—SHOWING "BANNER" COUNTIES AS REGARDS TOTAL PRODUCTION AND PRODUCT PER ACRE IN THE VARIOUS AGRICULTURAL REGIONS OF THE STATE.

REGIONS ACCORDING TO PRODUCT PER ACRE.	Average product per acre, fraction of a bale (475 pounds).	COUNTY IN EACH REGION HAVING HIGHEST TOTAL PRODUCTION.						COUNTY IN EACH REGION HAVING HIGHEST PRODUCT PER ACRE.					
		Name.	Rank in product per acre in the State.	Cotton acreage.	Total production in bales.	Product per acre, fraction of bale.	Rank in total production in the State.	Name.	Rank in total production in the State.	Cotton acreage.	Total production in bales.	Product per acre, fraction of bale.	Rank in product per acre in the State.
Coosa Valley region	0.401	Talladega	11	32,841	11,832	0.360	24	Cherokee	28	24,388	10,777	0.442	2
Coal Measures region	0.345	Marshall	27	16,412	5,358	0.326	44	DeKalb	56	7,469	2,859	0.383	7
Oak and Hickory Uplands, with Short-leaf Pine	0.329	Pickens	26	52,651	17,283	0.328	14	Fayette	52	12,331	4,268	0.346	19
Tennessee Valley region	0.324	Madison	47	72,838	20,679	0.284	10	Limestone	16	44,334	15,724	*0.355	14
Gravelly Hills, with Long-leaf Pine	0.304	Tuskaloosa	24	33,773	11,137	0.330	25	Tuscaloosa	25	33,773	11,137	0.330	24
Oak and Hickory Uplands, with Long-leaf Pine	0.302	Wilcox	18	77,076	26,745	0.347	4	Wilcox	4	77,076	26,475	0.347	18
Long-leaf Pine region	0.302	Washington	8	3,280	1,246	0.380	59	Baldwin	62	1,384	638	0.461	1
Metamorphic region	0.301	Chambers	54	70,934	19,476	0.275	11	Cleburne	54	9,156	3,600	0.393	6
Central Prairie region	0.274	Dallas	45	115,631	33,534	0.290	1	Lowndes	3	98,200	29,356	0.299	41

* Colbert has the same product per acre as Limestone.

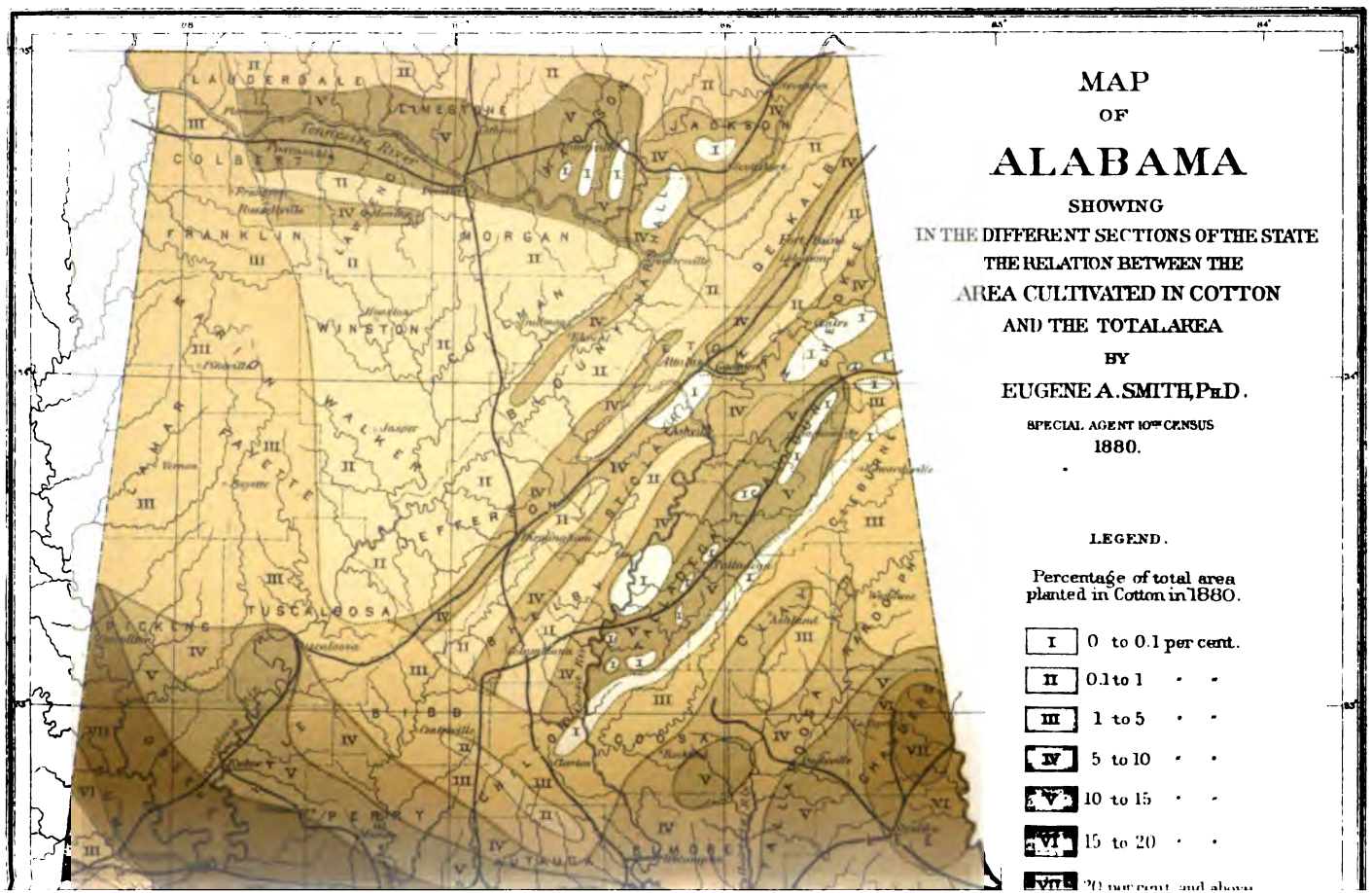
BANNER COUNTIES OF THE STATE.—As regards total production—Dallas, 33,534 bales; as regards product per acre (omitting those whose product is less than 100 bales)—Baldwin, 0.461 bales; as regards percentage of tilled land in cotton—Russell, 61 per cent.; as regards cotton acreage per square mile—Montgomery, 152 acres; as regards bales per square mile—Montgomery, 43 bales.

AREAS OF GREATEST PRODUCTION.—The statistical map accompanying this report shows in each region the percentage of the total area planted in cotton; and since the differences in product per acre in the several agricultural regions are comparatively slight, this map shows also approximately the percentage of the whole crop produced in each region.

Upon examination of this map, or of the statistical tables given on pages 298, 299, we see that the Central prairie region produces 40 per cent. of the entire cotton crop of the State, the Oak, hickory, and long-leaf pine region 17 per cent., the Tennessee Valley 12 per cent., the Metamorphic 10 per cent., the Coosa Valley eight per cent., the Gravelly Hills five per cent., the Short-leaf pine uplands four per cent., the Coal-measures region three per cent., and the Long-leaf pine region less than one per cent. But these relations will be much more clearly shown if we take into consideration also the relative areas of these regions and rate them according to the number of bales to the square mile. The several regions will then rank as follows:

	Bales to the square mile.
1. Central Prairie region	30
2. Metamorphic region	16
3. Tennessee Valley region	15
4. Coosa Valley region	13
5. Oak, Hickory, and Long-leaf Pine region	13
6. Oak, Hickory, and Short-leaf Pine region	9
7. Gravelly Hills	9
8. Coal Measures	4
9. Long-leaf Pine region	1

By this arrangement we are able to recognize three well-defined areas of large production in the State. These are: 1, the Central cotton belt; 2, the Tennessee Valley; 3, the Coosa Valley. The first of these areas produces at least



MAP
OF
ALABAMA

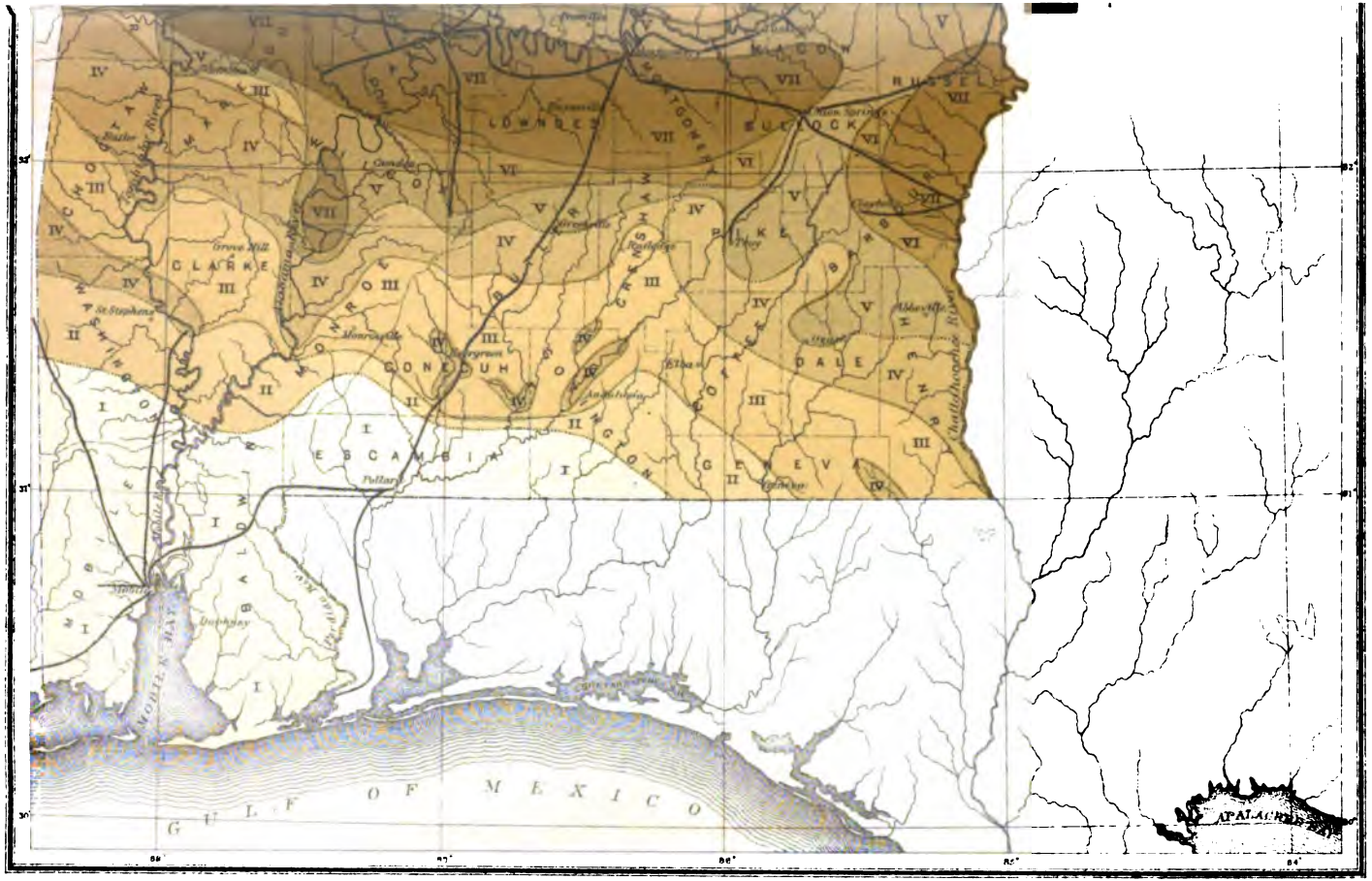
SHOWING
IN THE DIFFERENT SECTIONS OF THE STATE
THE RELATION BETWEEN THE
AREA CULTIVATED IN COTTON
AND THE TOTAL AREA
BY

EUGENE A. SMITH, PH.D.
SPECIAL AGENT 10TH CENSUS
1880.

LEGEND.

Percentage of total area planted in Cotton in 1880.

I	0 to 0.1 per cent.
II	0.1 to 1 " "
III	1 to 5 " "
IV	5 to 10 " "
V	10 to 15 " "
VI	15 to 20 " "
VII	20 per cent. and above


CLARKE
CONECUH
ESCAMBIA
BALDWIN
MOBILE
GENEVA
DALE
BUTLER
CRENSHAW
LOWNDES
MONTGOMERY
BARBOUR
PIKE
BULLOCK
MACON
RUSSELL
GULF OF MEXICO
MOBILE BAY
Grove Hill
St Stephens
Monroeville
Pollard
Evergreen
Greenville
Troy
Union Springs
Tuskegee
Eufaula
Clayton
Ozark
Dothan
Chattahoochee River
Alabama River
Tombigbee River
Escambia River
Perdido Bay
Scale
25 0 25 50 75 100 MILES

60 per cent. of the cotton crop; the second, 12 per cent.; the third, eight per cent.; while the remaining 20 per cent. is produced by the rest of the State.

The nucleus of the Central cotton belt is composed of the 12 counties of prairie region, together with Chambers and Lee counties and the southern portion of Tallapoosa county of the Metamorphic region. On each side of this nucleus there is a margin consisting of the adjacent portions of the counties of the Short-leaf pine uplands and Gravelly Hills on the north, and of the Oak, Hickory, and Long-leaf Pine Uplands on the south, in which the cotton production assumes nearly as great proportions as in the Prairie belt itself. In this way are included the southern parts of Pickens, Tuscaloosa, Autauga, and Elmore counties, and the northern parts of Wilcox, Butler, Crenshaw, Pike, and Henry counties.

The width of this Central cotton belt across the State is not much less than 75 miles, and the cotton production throughout the area thus defined is 20 bales and upward to the square mile.

Of the counties which form the nucleus of the Central cotton belt Dallas has the largest total production, because of its greater area; but if we take into account the differences of area, Montgomery occupies the first place, producing 43 bales to the square mile. After Montgomery come Lowndes with 40 bales, Dallas and Bullock with 34 each, Chambers with 32, and so on down the list, ending with Tallapoosa, which has 17 bales to the square mile. It will be seen by reference to the tables that some of the marginal counties of this Central belt show a yield for the whole county of 20 bales and upward to the square mile, which would, of course, bring up the yield of the portion of the county actually embraced in the Central region.

The second well-marked area of large production is found in the Tennessee Valley, with its greatest intensity along the immediate valley of the river, and the relative importance of the several counties here included in the production of cotton may be approximately measured by the relative proportion of the red or valley lands in the area of each. Applying the test of area devoted to cotton, we find

that the counties rank as follows: Madison, Limestone, Lawrence, Lauderdale, Colbert, Jackson, Morgan, and Franklin; but in eliminating the disturbing influence of difference in area, and taking account also of the product per acre, their rank as regards the number of bales to the square mile becomes: Limestone, Madison, Lawrence, Colbert, Lauderdale, Morgan, Jackson, and Franklin. Of these counties only the first two produce over 20 bales to the square mile.

The third large cotton-producing area is the Coosa Valley. In actual production to the square mile this falls behind the other two regions, being 13 bales, while that of the Tennessee Valley is 15, and that of the Central cotton belt 20 bales and upward. Both in total production and in cotton acreage, and especially in the number of bales to the acre, the counties of this region fall behind those of the two preceding. Talladega county stands first, with 18 bales to the square mile; then come Calhoun, Cherokee, Etowah, Saint Clair, and lastly Shelby, with nine bales.

We have thus seen where the great proportion of the cotton crop of Alabama, 80 per cent., is produced. As regards the rest of the State not much more need be said, except concerning the Coal Measures and the Long-leaf Pine regions, which show a production of four bales and one bale respectively to the square mile. With regard to the former region, it is to be remarked that the greater part of the cotton is produced in the valleys which traverse it, and not upon the soils of the true Coal Measures. Winston and Cullman may be taken as fair representatives of this region.

Population and Cotton Production.—Taking the State as a whole, the cotton production of Alabama is 0.55 bale to the inhabitant, or little more than a bale for every two inhabitants. This proportion varies in the different agricultural regions. In the Tennesse Valley and the Gravelly Pine Hills the proportion is exactly a bale to two inhabitants; in the Short-leaf Pine Uplands the proportion is a little more than a bale to two inhabitants, and in the Coosa Valley it is slightly less. In the Central Prairie region the proportion is a bale and a half, and in the Oak, Hickory,

and Long-leaf Pine Uplands a bale and a quarter to every two inhabitants. In the last named region, however, there are parts of some of the counties immediately adjoining the Prairie region in which the same proportion probably obtains as in the Prairie region itself. The same is true of the counties of Chambers and Lee; so that for the great Central cotton belt the proportion is about three-fourths of a bale to the inhabitant.

Following out these relations a step further, we find that over 55 per cent. of the colored population of the entire State is to be found in the Central cotton belt, where about 60 per cent. of the cotton is produced. Something over 10 per cent. of the blacks are found in the second cotton area, the Tennessee Valley, and about 5 per cent. in the Coosa Valley. This accounts for more than 70 per cent. of the colored population, which is thus concentrated in the three large cotton-producing areas of the State, where about 80 per cent. of the cotton crop is produced.

The distribution of the whites in the same region is as follows: In the Central cotton belt, about 18 per cent.; in the Tennessee Valley, about 16 per cent.; and in the Coosa Valley, about 12 per cent.; thus accounting for about 46 per cent. of the white population, as inhabiting the three large cotton-producing areas, against 70 per cent. of the blacks in the same areas. The other regions of the State which produce the remaining 20 per cent. of the cotton support 54 per cent. of the white population, but less than 30 per cent. of the blacks. Since the proportion of the white to the black population in the whole State is about 1.1 to 1, or not far from equal, it seems to follow that the greater part of the cotton crop of Alabama is produced by the negroes.

PRODUCT PER ACRE, AND ITS RELATION TO POPULATION.—In product per acre Alabama stands No. 13 of the fourteen principal cotton-producing States of the Union. Other things being equal, the product or yield per acre may be taken as an index to the fertility of a soil, and if we apply this test to the several agricultural regions of Alabama, they take the following rank:

1, Coosa Valley; 2, Coal Measures; 3, Oak, Hickory, and

Short-leaf Pine Uplands; 4, Tennessee Valley; 5, Gravelly Hills; 6, Oak, Hickory, and Long-leaf Pine Uplands; 7, Long-leaf Pine region; 8, Metamorphic; and 9, Central Prairie region.

Putting Chambers and Lee together with the counties which constitute the *Prairie region*, we have the nucleus of the Central cotton belt as above defined. In all these counties the average product per acre is 0.27 of a bale. This somewhat unexpected result cannot be considered as due to the relative infertility of the soils of this belt, for correspondents unite in giving as the average yield on the fresh lands of this region from 700 to 1,600 pounds of seed-cotton, or from one-half a bale to more than a bale to the acre, and the chemical analyses show that these soils in their virgin state are among the very best in the State. We are led, therefore, to the conclusion that the soils of the great cotton belt have been exhausted by improvident culture, and, as a matter of fact, we know that in many parts of this belt cotton is planted year after year upon the same soils without rotation with other crops, and without an attempt at maintaining the fertility by the use of manures. In the other parts of the State where cotton is produced, a selection is generally made of the better soils, rotation of crops is more generally practiced, and in some sections fertilizers are in more general use.

That the character of the laborers and the system of farming practiced are largely concerned in determining the yield, can not, on general principles, be denied, and we find ample proof that these two things are responsible in no small degree for the results above shown.

The *Central cotton belt* is generally a region of large farms or plantations, in which the laborers are chiefly negroes, as seen in the tables. As a rule, these laborers do not own the land, have no interest in it beyond getting a crop from a portion of it, which they rent either for a sum of money or for a share of the crop, and are not interested in keeping up the fertility, at least not to the extent of being led to make any attempts at the permanent improvement of the same. In the case of the owner of the land, while the conditions are different, the result is the same. He is, of

course, interested in the improvement of his land; but to supply the fertilizers for a large plantation, when he cultivates it by hired labor, would cost more than he usually has to expend, and where the share system, or that of renting prevails, he is still further removed from personal care of the land; and thus from all causes there is an exhaustive cultivation of the land, without any attempt at maintenance or restoration of its lost fertility.

In addition to these, the system of advances or credit, so prevalent throughout the cotton-producing parts of the State, is not without its evil influence for the laborer, and too often the owner of the land is obliged to get advances of provisions from their merchants, for the payment of which the crop is mortgaged; and as cotton is the only crop that will always bring ready money, its planting is usually insisted on by the merchants making the advances, and selected by the farmer as a means of providing for payment. In this way, cotton comes to be the paramount crop, and there is little chance for rotation with other things.

In this connection, it will be instructive to read the reports given under Section IV, treating of cultural details. It will there be seen that the system of credits in the large cotton-producing regions prevails to such an extent that the whole cotton crop is usually mortgaged before it is gathered; and when we consider that the prices charged for provisions, etc., thus advanced, are at least fifty per cent. higher than regular market rates, and that the cost of producing cotton is given by our correspondents, almost without exception, at eight cents a pound, it will need very little calculation to show that the laborer who makes a profit of only two or three cents a pound, or $12 to $15 a bale, on his cotton, will have the chances too greatly against him ever to be out of debt to his merchants, when he relies solely upon this crop to provide the money; and the exorbitant interest on the money advanced is not likely to be lessened so long as the merchants' risks continue to be as great as they are.

In the *Tennessee and Coosa Valleys*, which are also large cotton-producing sections, a similar state of things may be observed. In Madison and Talladega counties the blacks outnumber the whites, and in both we find the product per

acre falling far below the average of the region in which they are situated. Thus Madison shows a product of 0.28 bale, against the average of 0.32 for the whole Tennessee Valley; and Talladega a product of only 0.36 bale, when the average for the Coosa Valley region, of which it is a part, is 0.40. Wherever the black population is in excess of the white we may take it for granted that the system of large farms rented out to the negroes prevails, and the inevitable result of this system of farming thus becomes apparent in these sections also.

In the other agricultural regions of the State, and in most of the counties also of the Tennessee and Coosa Valleys, the farms are, as a rule, small, and are cultivated by their owners, with the assistance of such labor as may be hired from time to time. In all these cases provisions are produced on the farm, and cotton is planted as a secondary crop. There is thus some chance for selection of the soils and for rotation of crops; and when a man cultivates his own farm, fertilizers are in more general use, so that even with soils naturally much inferior to those of the main cotton-producing regions the average product per acre is much higher in these regions of small production.

In the *Coal-Measures* region, which takes rank as third in product per acre, there are no large farms, and the whites outnumber the blacks nearly nine to one (a sure sign of poor soil), the farmers generally owning the land which they cultivate.

Until very recently only the lands of the valleys traversing the Coal Measures have been planted in cotton, so that the product per acre as given in the tables is an index rather of the fertility and capabilities, under proper culture, of the calcareous valley soils than of those directly derived from the rocks of the Coal Measures. In Winston and Cullman there are no such valley soils, hence the product per acre of these counties may be taken as representing that of the soils of the Coal Measures generally, viz: 0.26 to 0.28. In these regions it is usual to plant only the better kinds of soils in cotton, and of late only with the application of some kinds of commercial fertilizers. These sandy lands, which have a clayey substratum, are more and more every year,

with moderate quantities of fertilizers, coming into use in the production of cotton, and the same may also be said of the siliceous portions of the valley lands of the regions just spoken of. It is now thought to be pretty well established that these poorer sandy lands, with the aid of moderate quantities of fertilizers, make in the long run better-paying and more certain crops of cotton than the intrinsically better classes of soils without the fertilizers.

In the *Short-leaf Pine Upland* counties the whites are more than twice as numerous as the blacks. The same conditions, therefore, hold here as in the case just mentioned. The product per acre is 0.33 per bale.

The soils of the *Gravelly Hills* are practically the same as those of the Short-leaf Pine lands, but the product is 0.30 bale to the acre, and that of the Oak, Hickory, and Long-leaf Pine about 0.30, with likewise very similar soils. In these the two races are present in nearly equal proportions. These figures furnish an additional illustration of what has been shown above, viz: that the greater the proportion of blacks among the population the more prevalent will be the system of large farms worked on shares, or by renting, and the smaller will be the yield of the land so cultivated, because of the inherent vices of the system.

The concentration of the black population in the great farming regions of the State, which are also the regions of the originally most fertile soils, is amply shown by Table III; and so closely does this class of the population follow the best lands that the density of the colored population of any region might almost be taken as an index of the fertility of its soils. The white population is much more evenly distributed over good and poor lands alike, so that the proportion between the two races varies with the fertility of the soils. (*a*)

a The negroes were originally brought together upon these great cotton-producing areas as the slaves of the wealthy planters, who bought up the greater part of the best lands in the State: Since the war they have remained, practically speaking, in the same places where as laborers in the cotton-field (with which they were most familiar) they could always be sure of employment and of a good living without too severe labor. The social attractions also of these great centers of negro population have not been without their influence in keeping the race together.

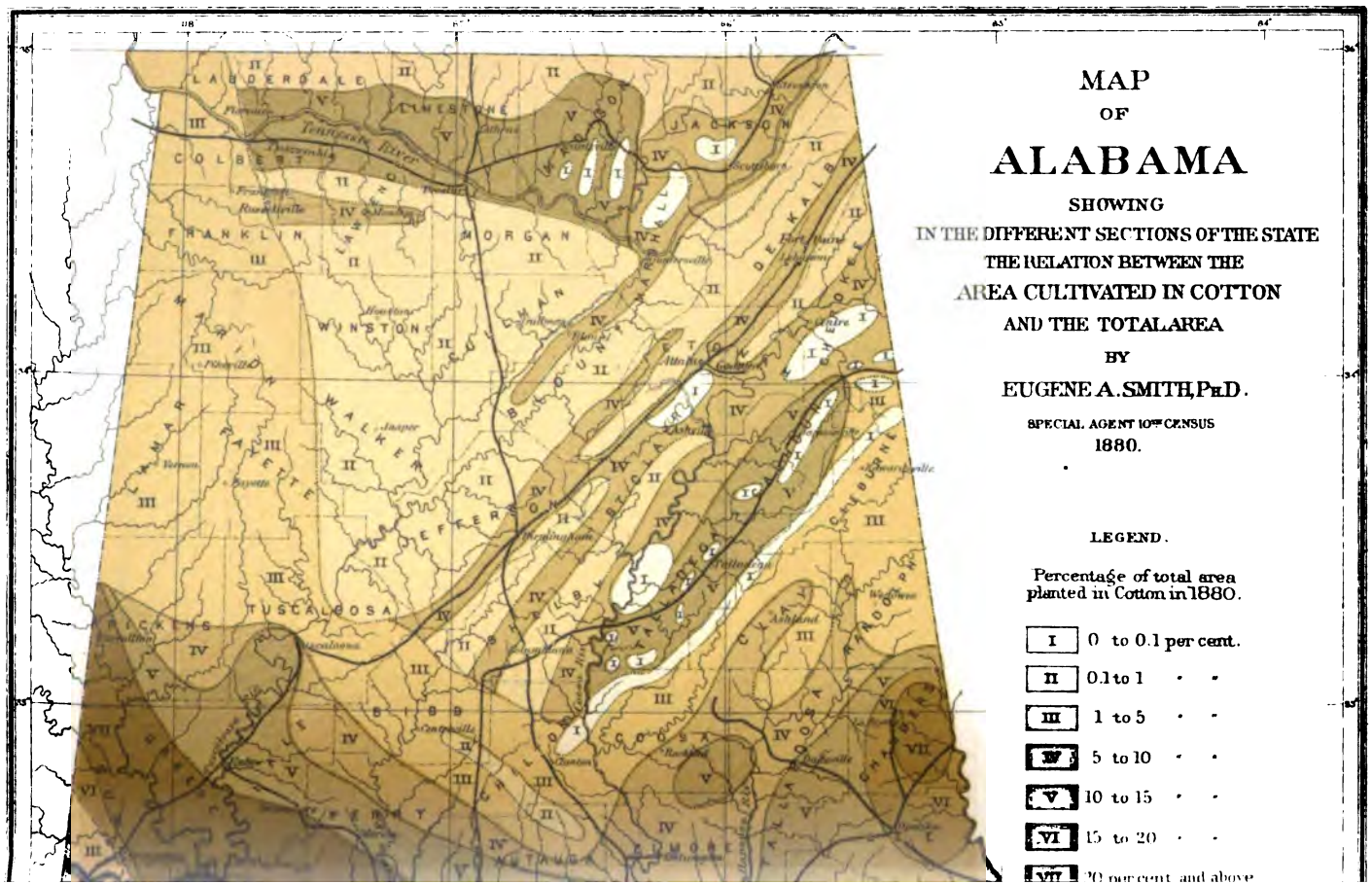
TABLE III.—SHOWING POPULATION AND COTTON PRODUCTION IN EACH AGRICULTURAL REGION OF THE STATE.

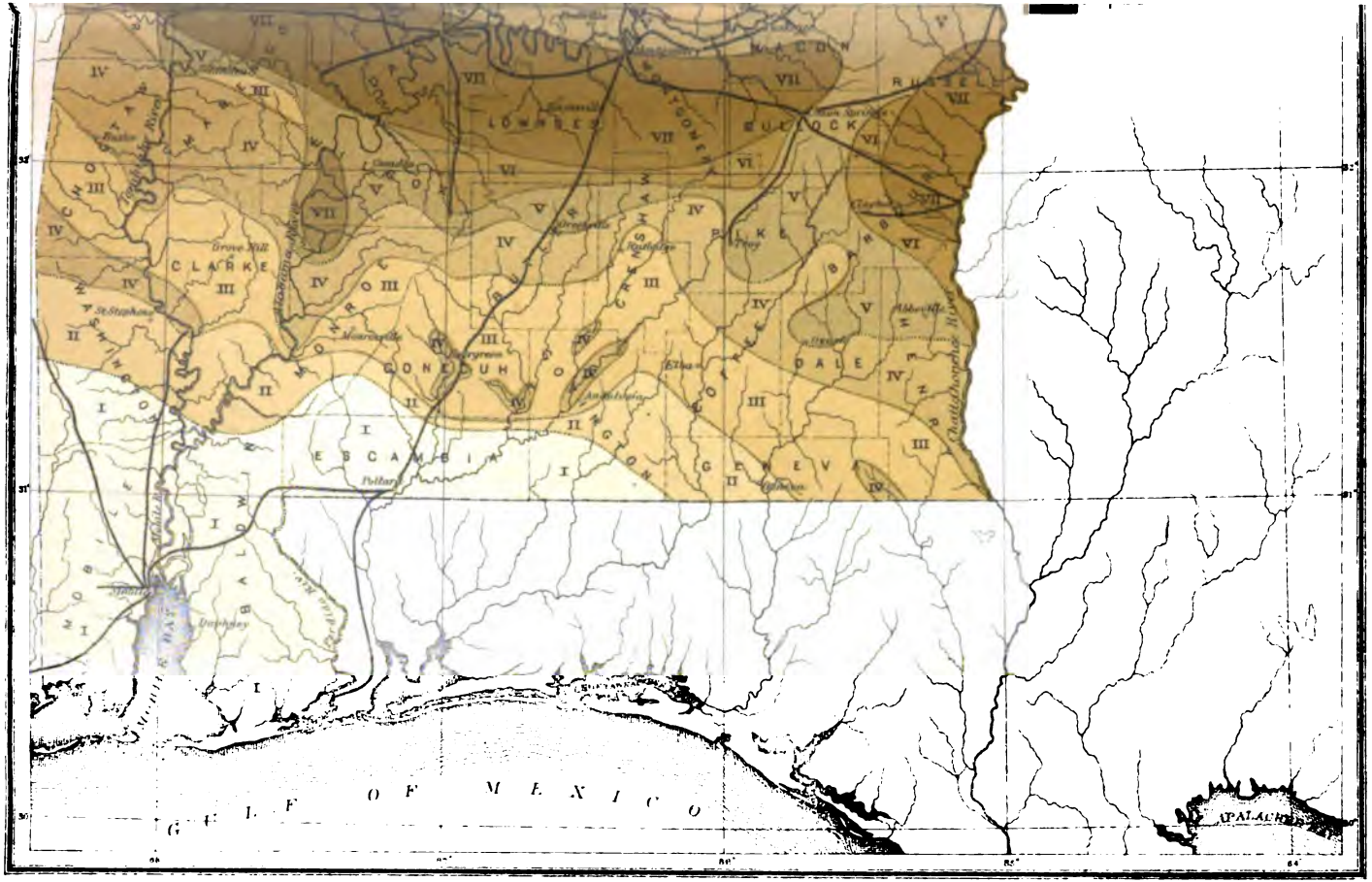
	Area in sqare miles.	POPULATION.			COTTON PRODUCTION.										
							Av'ge per acre.				Total in tons				
		Total.	White.	Color'd	Acres.	Bales.	Fraction of bale (475 pounds.)	Seed-cotton.	Lint.	Seed.	Lint.	Seed.	Percentage of State's total production.	Cotton acreage per square mile.	Bales per square mile.
Total	51,540	1,262,505	662,185	600,320	2,330,086	699,654	0.30	429	143	286	166,168	332,336	100	45	14
Metamorphic region	4,460	129,705	85,072	44,633	236,745	71,285	0.30	429	143	286	16,930	33,860	10	53	16
Coosa Valley region	3,930	109,155	78,345	30,977	131,505	52,699	0.40	570	190	380	12,516	25,032	8	33	13
Coal Measures region	5,070	85,988	77,032	8,956	62,863	21,692	0.35	498	162	332	5,152	10,304	3	12	4
Tennessee Valley region	5,760	168,502	107,157	61,345	260,861	84,447	0.32	456	156	304	20,056	40,112	12	45	15
Oak and hickory uplands, with short-leaf pine	3,060	53,120	36,813	16,307	87,496	28,806	0.33	471	157	314	6,841	13,682	4	29	9
Gravelly Hills, with Long-leaf Pine	3,990	75,847	42,898	32,949	122,587	37,229	0.30	429	143	286	8,842	17,684	5	31	9
Central Prairie region	9,220	376,061	87,877	288,184	1,014,606	278,508	0.27	385	128	256	66,146	132,292	40	110	30
Oak and hickory uplands, with long-leaf pine.	9,470	186,633	99,371	87,262	399,357	120,739	0.30	429	144	286	28,676	57,352	17	42	13
Long-leaf Pine region	6,580	77,494	47,707	29,707	14,066	4,249	0.30	429	143	286	1,009	2,018	1	5	1

TABLE IV.—SHOWING "BANNER" COUNTIES AS REGARDS TOTAL PRODUCTION AND PRODUCT PER ACRE IN THE VARIOUS AGRICULTURAL REGIONS OF THE STATE.

REGIONS ACCORDING TO PRODUCT PER ACRE.	Average product per acre, fraction of a bale (475 pounds).	COUNTY IN EACH REGION HAVING HIGHEST TOTAL PRODUCTION.						COUNTY IN EACH REGION HAVING HIGHEST PRODUCT PER ACRE.					
		Name.	Rank in product per acre in the State.	Cotton acreage.	Total production in bales.	Product per acre, fraction of bale.	Rank in total production in the State.	Name.	Rank in total production in the State.	Cotton acreage.	Total production in bales.	Product per acre, fraction of bale.	Rank in product per acre in the State.
Coosa Valley region	0.401	Talladega..	11	32,841	11,832	0.360	24	Cherokee..	28	24,388	10,777	0.442	2
Coal Measures region	0.345	Marshall....	27	16,412	5,358	0.326	44	DeKalb....	56	7,469	2,859	0.383	7
Oak and Hickory Uplands, with Short-leaf Pine	0.329	Pickens	26	52,651	17,283	0.328	14	Fayette....	52	12,331	4,268	0.346	19
Tennessee Valley region	0.324	Madison....	47	72,838	20,679	0.284	10	Limestone	16	44,334	15,724	*0.355	14
Gravelly Hills, with Long-leaf Pine	0.304	Tuskaloosa .	24	33,773	11,137	0.330	25	Tuscaloosa	25	33,773	11,137	0.330	24
Oak and Hickory Uplands, with Long-leaf Pine	0 302	Wilcox	18	77,076	26,745	0.347	4	Wilcox ...	4	77,076	26,475	0.347	18
Long-leaf Pine region	0 302	Washington.	8	3,280	1,246	0.380	59	Baldwin ..	62	1,384	638	0 461	1
Metamorphic region	0.301	Chambers...	54	70,934	19,476	0.275	11	Cleburne..	54	9,156	3,600	0.393	6
Central Prairie region	0 274	Dallas.....	45	115,631	33,534	0.290	1	Lowndes..	2	98,200	29,356	0 299	41

* Colbert has the same product per acre as Limestone.


MAP
OF
ALABAMA
SHOWING
IN THE DIFFERENT SECTIONS OF THE STATE
THE RELATION BETWEEN THE
AREA CULTIVATED IN COTTON
AND THE TOTAL AREA
BY
EUGENE A. SMITH, PhD.
SPECIAL AGENT 10TH CENSUS
1880.
LEGEND.
Percentage of total area planted in Cotton in 1880.
I 0 to 0.1 per cent.
II 0.1 to 1 " "
III 1 to 5 " "
IV 5 to 10 " "
V 10 to 15 " "
VI 15 to 20 " "
VII 20 per cent and above
LAUDERDALE
COLBERT
FRANKLIN
MORGAN
LIMESTONE
JACKSON
DE KALB
WINSTON
MARION
WALKER
FAYETTE
TUSCALOOSA
PICKENS
GREENE
SUMTER
MARENGO
PERRY
BIBB
CHILTON
COOSA
CLAY
RANDOLPH
CHEROKEE
Tennessee River
Coosa River
Black Warrior River
Tombigbee River


CLARKE
CONECUH
ESCAMBIA
BALDWIN
MOBILE
WASHINGTON
CHOCTAW
MARENGO
WILCOX
LOWNDES
MONTGOMERY
BUTLER
CRENSHAW
PIKE
COVINGTON
DALE
GENEVA
HENRY
HOUSTON
GULF OF MEXICO
Julius Bien & Co lith
Scale
25 0 25 50 75 100 MILES

FERTILIZERS NATURALLY OCCURRING IN ALABAMA.—As to the necessity of using some means for maintaining the fertility of soils there can now be no two opinions, and exhaustion is of course, only a matter of time in the case of any soil which is continuously cultivated without restoring to it in some way a portion at least of the plant-food abstracted by the crops produced upon it. It becomes, therefore, a matter of the greatest importance to know what are the resources of the State for keeping up this fertility.

The two classes of manures generally distinguished are *stimulant* and *nutritive*. To the first class belong those substances which, like lime, serve chiefly to render available the plant-food already present in the soil, but in such a condition as to be not readily assimilated by the growing crop. To the second class belong those mixtures which contain some or all of the elements of plant-food, chief among which are nitrogen, potash, and phosphoric acid.

Stimulant Manures.—In nearly all parts of Alabama limestone is easily accessible, from which lime for agricultural purposes may be prepared in sufficient quantity. The use of a merely stimulant manure does not keep up the soil fertility, but on the contrary enables crops to draw heavily upon its reserve of plant-food, and thus causes its available portion to be exhausted all the more speedily. Lime is also extensively used to promote the rapid decay of vegetable matter, to convert it into humus, and in this way also it is beneficial to soils. The presence of lime in soils has further the effect of increasing their capacity for resisting drouth and improving their tilling qualities generally. In addition to all these, it is directly necessary to the growth of all plants. It is chiefly, however, as a stimulant and as a promoter of the formation of humus from vegetable matter that it finds an extended use in agriculture.

Nutritive Manures.—Of the partial manures belonging to this class the most extensively used are the guanos, superphosphates, and ground bones, the principal ingredients furnished by these being potash, phosphoric acid, and ammonia. Cotton-seed or cotton-seed meal is also rapidly coming into use as a fertilizer, and it is one of the best, since it contains all of the essential ingredients of plant-food, and

may therefore be conaidered as more nearly a complete manure than any of the others mentioned. In the marls of the State, however, we have a class of fertilizers which combine the qualities of a stimulant with those of a nutritive manure, and they are therefore worthy of a careful attention. These marls are found in the Cretaceous and Tertiary strata of the southern division of the State, and are of several varieties. In all the marls there is a certain proportion of nutritive matter in addition to the lime.

Cretaceous Marls.—Materials which might profitably be used as fertilizers occur in all three of the subdivisions of the Cretaceous formation in Alabama.

The three subdivisions of this formation have been enumerated above in considering the general characters of the Southern Division, and the main features of each given. For our present purposes the following additional details are needed:

The Eutaw Group.—The lower half of this group consists of beds of micaceous sand and laminated clay in many alternations. The sands and sandy clays are sometimes indurated and often contain indeterminable impressions of leaves, and stems, the latter lignitized and encased in a shell of iron pyrites. These beds lie at the base of the formation, while above them a bed of light yellowish cross-bedded sands fifteen feet in thickness, surmounted by about the same thickness of mottled clay—purple and gray—forms a conspicuous and persistent feature of the outcrops along the Warrior river banks.

The upper half is made up of laminated clays and sands alternating with each other many times; enclosing one or two beds of pebbles, and characterized by the occurrence of numerous lignitized tree trunks. The clays are mostly of blue color, as are also most of the sands where they have not been exposed to oxidation. On exposure they assume a yellowish color. The sands are usually strongly marked with cross-bedding, and are, as a rule, *glauconitic*, the proportion of this mineral increasing upwards. Near the summit of the Eutaw series and just below the Rotten Limestone, occurs the best bed of greensand (glauconite) yet observed. The thickness of the bed is three or four feet, and the pro-

portion of greensand is estimated to be about 50 per cent. Analysis has not yet been made of the material from this particular bed, which was only recently discovered, but it will probably equal in value the better kinds of New Jersey greensand. At low stages of the water this bed is exposed along the banks of the Warrior river from Choctaw Bluff to Erie, and there would be no difficulty in getting it up. As a potash manure, it might supply the place of the *kainite* of the German mines, and cost less.

A specimen from these uppermost glauconitic beds of the Eutaw group, was collected from the Turkey Creek hills near Pleasant ridge, in Greene county. This is inferior to the Choctaw Bluff greensand, but has strong fertilizing properties, as is evidenced by the luxuriant growth of the trees and weeds along the slopes of the hills. The composition of this substance is given in the table on the next page, (No. 132).

The Rotten Limestone.—This rock, which has in Alabama a thickness of more than a thousand feet, has itself the composition of marl, containing from 20 to 85 per cent. of carbonate of lime, which is the constituent upon which its chief value as a stimulant manure depends; but in addition to the carbonate of lime this rock contains also a variable percentage of phosphate of lime, ranging, according to Dr. Mallet's analyses, between 0.37 and 0.54 per cent.; of potash, from 0.04 to 0.11 per cent.; and of silica in a condition readily soluble in dilute acids, from 0.06 to 0.19 per cent. Several analyses of Rotten Limestone from different parts of the State are to be found in Professor Tuomey's second report.

Taken as a whole, this group is not very rich in fossils, but the upper and lowermost strata are both highly fossiliferous, and contain several beds which are in the main made up of shells of the oyster family. Some of these beds are also very rich in glauconite, as may be seen from the subjoined analyses of a greensand marls from near Epes' Station, (No. 145.)

This sample was not collected by myself, and I am, therefore, unable to give with certainty the exact position, either

geographically or geologically, though it probably occurs among the uppermost strata of the Rotten Limestone.

The marls and greensands of these groups of Cretaceous formation have not yet been particularly searched for along the Alabama river, and in the eastern parts of the State. There is little reason to doubt that the same beds will be found in similar position along that river.

ANALYSES.

No. 132. *Greenish sand*, Pleasant Ridge, Greene county. This consists of grains of quartz sand, often coated with a green material, scales of mica, rounded and flattened lumps of greensand, and fragments of lignite. The greensand makes only a small proportion of the whole mass, and the marl would hardly pay for the hauling; but its effects upon the soils, over which it is distributed by natural causes, are seen in the luxurious vegetation of the lands which receive the washings of these hills. In other localities it is quite probable that a richer material may be found.

No. 145. *Greensand marl* (Cretaceous), Epes', Sumter county.

GREENISH SAND, AND GREENSAND MARL (CRETACEOUS).

	GREENE COUNTY.	SUMTER COUNTY.
	Greenish sand.	Greensand marl.
	No. 132.	No. 145
Insoluble matter	76.734	57.617
Soluble silica	1.162 } 77.896	1.778 } 59.395
Potash	0.398	1.439
Soda	0.115	0.118
Lime	0.899	8.922
Magnesia	0.592	0.193
Brown oxide of manganese	0.170	0.101
Peroxide of iron	8.457	13.988
Alumina	0.091	2.161
Phosphoric acid	0.051	0.143
Sulphuric acid	0.789	0.160
Carbonic acid	.....	10.628
Water and organic matter	10.216	2.260
Total	99.674	99.508

The marl, while it contains less lime than the ordinary

Rotten Limestone, is likely to prove valuable as a fertilizer because of its high percentage of potash.

According to Dr. Loughridge, there is a bed of Cretaceous greensand marl extending along the Chattahoochee river bluff for fifteen miles, with an average thickness of ten or fifteen feet. It contains about two per cent. of potash, and would undoubtedly be valuable to the farmers within reach of it.

Dr. Mallet partially analyzed a sample of greensand from near Gainesville, and found in it: Potash, 2.437 per cent.; Phosphoric Acid, 0.183 per cent.; and Carbonate of Lime, 0.87 per cent.

I am not able to say with certainty to which of the divisions of the Cretaceous these two occurrences are to be referred.

The upper or Ripley group of the Cretaceous is in part composed of bluish micaceous marls containing greensand. In the region of their occurrence these marls give rise to lasting and productive soils, well known in the low grounds of Cowikee and Bear creeks in Barbour and Russell counties.

Dr. Mallet has made several partial analyses of this class of marls, of which the following may be taken as a representative:

Bluish or greenish-gray marl, containing grains of sand, particles of mica, and fragments of shell, from below Eufaula:

	Marl.	Limestone.
Carbonate of lime	13.47	88.82
Carbonate of magnesia	1.01	2.18
Peroxide of iron	3.21	.....
Alumina	1.08	0.94
Phosphoric acid	0.18	0.23
Silicic acid (soluble in acid)	0.54	.....
Insoluble matter (finely divided clay, sand, and specks of mica)	79.14	7.20
	98.63	99.37

In the same formation there are beds of hard and tolerably pure limestone, which might be used in the preparation of lime for agricultural purposes. One of the samples analyzed by Dr. Mallet (see above) from Chunnenugga ridge,

Macon county, was a highly fossiliferous limestone, the shells for the most part white crystalline carbonate of lime, and the limestone cementing them together of a light brownish-gray color, containing numerous small cavities, often lined with carbonate of lime. This is the character of much of the limestone of the Chunnenugga ridge.

Tertiary Marls.—A special examination was made by me, for the purposes of this report, of the marls and other mineral fertilizers of the Tertiary formations of Alabama. These materials may be conveniently arranged in two classes, viz: I, the greensands, and II, the calcareous marls; and the latter into (*a*) those which contain greensand, and (*b*) those whose value depends chiefly upon their content of lime.

I. *The Greensands.*—The subdivisions of the Tertiary in Alabama have been given above in the same connection with those of the Cretaceous. Below the Buhrstone group lie some three hundred to four hundred feet of strata (perhaps more) classed as Lignitic and Flatwoods. The latter of these, at the very base of the Formation, consists of laminated clays, which are, so far as yet known, devoid of fossils. The Lignitic consists of sands and clays, in the main of lignitic character; but interstratified with these at several horizons are beds of marine origin. The lowermost hundred feet of this group are formed by a black, shaly clay, which in places contains a few well preserved fossils, with nothing, however, approaching the character of a marl bed. These beds are seen along the Tombigbee, from Black Bluff down to Naheola (at the last named locality there is a thin marl bed), and on the Alabama, from Midway, just south of Prairie Bluff, down to Clifton. Overlying this black shale are about seventy-five feet or more of laminated gray clays and coarse grained sands strongly cross-bedded, and without any calcareous beds so far as yet known. These are seen on the Tombigbee, between Naheola and the mouth of Beaver Creek, above Nanafalia, and on the Alabama between Clifton and Coal Bluff. At least one, and perhaps other beds of lignite are included within these strata.

At Nanafalia landing, on the Tombigbee, and at Gullett's

and Black's Bluffs, on the Alabama, occurs one of the most remarkable of the marine deposits of this lower division of the Tertiary; it will be more particularly described below in the next section (under *Greensand Marls*). One of the beds of this group consists of a mixture of quartz grains, small, rounded or flattened lumps of greensand, and a few small particles of mica. The thickness of the deposit is only a foot or two; the color deep yellowish green. This greensand bed is best exposed where the Linden and Nanafalia road crosses Double Creek, in Marengo county. The analysis, No. 128, in the table of analyses of Tertiary marls on page 327, will show its composition. There are several beds of greensand occurring in connection with this Nanafalia deposit (which is more than fifty feet in thickness), and one of these is exposed on Gravel creek, in Wilcox county. It has been examined by Dr. Mallet, and the results of two partial analyses by him are here presented:

GREENSAND FROM GRAVEL CREEK, WILCOX COUNTY.

	No. 1.	No. 2.
	Per cent.	*Per cent.*
Potash	2.213	1.893
Lime	0.69	0.67
Phosphoric acid	Trace.	Trace.
Iron pyrites	Trace.	None.

Between Coal Bluff, on the Alabama, and the mouth of Pursley creek, just above Gullett's landing, there are several occurrences of greensand along the banks of the river, and one immediately over the bed of lignite at Coal Bluff also; but none of these have yet been subjected to analysis, though samples have recently been collected for that purpose.

On the Tombigbee, the corresponding beds would appear between the mouth of Beaver creek and Nanafalia, but in this part of the river there are no rock bluffs, but only banks formed of more recent deposits.

II. *Calcareous Marls; (a) Greensand Marls.*—The Nanafalia marl beds alluded to above are exposed along the

bluffs of the Tombigbee from Nanafalia down to Williams' Gin, nearly to Barney's Upper Landing, and on the Alabama from Gullett's Bluff down to within five miles of Yellow Bluff, at MacNeill's shoals. The best exposure is seen at Gullett's landing, where the lower half of the bluff (about fifty feet) consists of these shell beds. The greater part of this deposit is a mass of shells of a small oyster *(Gryphæa Thyrsæ)*. These shells are, throughout the entire thickness of this deposit, more or less mixed with greensand grains, which at intervals make a very considerable portion of the whole mass. A sample was selected from one of these beds at Nanafalia, in which the greensand was quite conspicuous, and its analysis is given in the table below, No. 127. This particular part of the marl is a mixture of grains of quartz sand, small rounded lumps of greensand, and fragments of shells, together with a large number of perfect or unbroken shells. As usual, where the proportion of greensand is greatest, the beds contain other species of shells besides the small oyster named. Along all the bluffs where the Nanafalia marl occurs there are at intervals of eight or ten feet projecting ledges of harder texture than the rest. These ledges are usually only more indurated aggregates of these small oyster shells, with very few other forms. The outcroppings of these Gryphæa beds may be traced across Marengo county by the prairie soils and lime hills to which they give rise, and into Wilcox, where, as already stated, they appear at Gullett's and Black's Bluff and below, on the Alabama river, and thence out along the course of Gravelly creek. How much farther eastward they may be followed, I am at present unable to say.

Some of the lower beds of this group are seen above Gullett's, in the direction of Coal Bluff, and Dr. Mallet has analyzed a sample, which consisted of greensand grains siliceous clay, fine quartz sand, fragments of shells, etc., and had the following composition :

GREENSAND SHELL MARL, COAL BLUFF, WILCOX COUNTY.

	Per Cent.
Potash	1.67
Phosphoric acid	1.00
Carbonate of lime	29.33
Iron Pyrites	10.57

The same chemist analyzed also some of the separate grains of greensand of this deposit, the mean of two analyses of which was as follows:

	Per Cent.
Silica	57.56
Alumina	6.56
Ferrous oxide	20.13
Lime	1.04
Magnesia	1.70
Potash	4.88
Water	8.17
Total	100.04

The value of marls of this kind depends not only on the carbonate of lime which they contain, but also upon the potash of the greensand, and are therefore more valuable in proportion to the per centage of greensand, and this proportion may be approximately estimated by the color, the deeper the green the better. A bed of greensand of very deep color occurs at Matthews' Lower Ferry, on the Alabama, at the foot of Wilcox Bar, among the beds included in the above description.

All the shell beds of this deposit might be profitably used where convenient of access, even where the per centage of greensand is small.

The localities above given of the outcroppings of this marl along the Tombigbee and Alabama rivers are also the best points from which it may be gotten for shipment or for local use.

These marls will some day come extensively into use. I have no doubt that a part at least of the productiveness of the soils of Black's Bend may be traced to their influence, while many of the rich limy or prairie spots scattered through Marengo along the line of outcrop of the beds, are very evidently produced by them.

Between this Nanafalia marl and the base of the Buhrstone rocks, are several other marine beds interstratified with lignitic deposits. Of these I shall mention only the most important. One may be seen at Turner's Ferry on the Tombigee, but it is thin and apparently of no great value. The same bed, apparently, occurs at the Tuscahoma bluff on the same river.

On the Alabama at Yellow Bluff, at Lower Peach Tree, and at Bell's Landing, occurs a greensand marl bed with very similar characters at all three localities. At the two localities last named, there is no doubt of their identity, while it yet remains uncertain whether the Yellow Bluff marl is the same or a different and lower bed.

But characters common to all, are the presence of greensand and of certain well marked species of shells, the occurrence of an indurated bed in the midst of, or at the top of the softer marl. This indurated bed has a great tendency to assume the shape of a series or string of rounded boulder-like masses which project from the faces of the bluffs or lie strewn at their bases, where they have fallen down in consequence of weathering. The thickness of this bed, including the indurated stratum, is some ten or fifteen feet, and while, as a whole, it is inferior to the Nanafalia marl, especially in extent, its effects upon the soil may be readily seen in a series of lime hills very much like those produced by the Nanafalia marls. These lime hills are best observed west of Lower Peach Tree, in the direction of Choctaw Corner, in Clarke county. On a preceding page, an analysis has been given, No. 140, of a lime hills soil which owes its origin to this marl bed. It does not, so far as I know, form any bluff on the Tombigbee.

The next occurrence of a greensand marl is the bed exposed in Cade's Bend and at Wood's Bluff, on the Tombigbee, and at Johnson's Wood Yard, below Bell's Landing on the Alabama. This and the preceding (Bell's Landing marl) are separated by only about 60 to 80 feet of lignitic strata. The Wood's Bluff marl is a greensand shell marl 10 to 15 feet in thickness, lying below some 25 to 30 feet of laminated clays and clayey marls of no agricultural value, but a rare collecting ground for the paleontologist.

The greensand marl, like that at Bell's Landing, has an indurated stratum which shows a tendency to form rounded boulder-like masses, and which differs from the rest of the marl only in being a tolerably hard limestone rock, while the rest is quite soft and easily worked. This indurated part is commonly near the top of the bed, but its position is not at all invariable, being sometimes near the middle.

With practically identical features, this bed may be traced from the vicinity of Butler, in Choctaw county, through Choctaw Corner, in Clarke county, to the Alabama river below Lower Peach Tree, and thence down the river to the locality mentioned, below Bell's Landing. Across the river it shows itself in the lime lands of the upper part of Flat creek in Monroe county.

In many places the indurated part of the bed forms an overhanging ledge from below which the softer marl has been washed out, and in a similar way caves of considerable extent are also produced, having the indurated marl as roof.

Two samples of the marl from this bed have been analyzed: the one from Mr. Hendrick's, near Butler, in Choctaw county, the same bed appearing in very many localities about that town. For analysis, see No. 126 of the table on page 327.

The other sample, analysis of which is seen in the table referred to, No. 130, was obtained from the "Natural Bridge" formed of this indurated stratum, from beneath which a small stream has washed out the softer material. This is about two miles west of Choctaw Corner, in Clarke county.

These, like all the greensand marls, owe their peculiar value to the greensand which they contain, hence the more pronounced the green color the better the marl. The 25 to 30 per cent. of carbonate of lime which they all hold is also, of course, of value.

The strata which lie above the Buhrstone group, as well as the Buhrstone rocks themselves, contain, at several horizons, a small proportion of greensand, but this mineral is by no means so abundant above, as it is below, the Buhrstone.

Just below the lowest of the aluminous and siliceous rocks which are so characteristic of this group, are two or more marl beds of no great value agriculturally. One of these shows the same tendency to form concretionary masses of harder texture than the rest, as was noticed in the cases of the marls of Wood's Bluff and Bell's Landing.

The base of the Bluff at McCarthy's ferry, in Choctaw county, is covered with these boulder-like masses, as is also

the case at the Hatcheetigbee Bluff. Near the water's edge, at the latter place, there is also a bed of well preserved shells of *Venericardia planicosta*. These occurrences are on the Tombigbee. On the Alabama, the very same marl, with its indurated boulders, may be seen just below Williams' Island, above Hamilton's Landing, near Turkey Shoals.

On the Tombigbee, at Mr. E. S. Thornton's place, a tolerably good bed of greensand occurs. This has not yet been analyzed. The same beds occur on the Alabama near the Lisbon Landing.

The lower portion of the Claiborne Bluff, on the Alabama river, consists of sandy, argillaceous, and calcareous beds, many of them fossiliferous, containing principally oyster shells. Most of these lower beds hold, also, notable quantities of greensand. A sample of one of these, analysis of which is No. 136 of the table on page 327, is composed of quartz grains, pulverulent carbonate of lime, clayey matter, and a few grains of greensand.

At the Coffeeville landing, on the Tombigbee river, these lower Claiborne beds are also seen. An analysis is given in the table (No. 138), of a sample taken from a loose pulverulent bed just below a hard ledge of similar composition.

It consists of quartz sand, comminuted shells, a small proportion of greensand grains, and an occasional particle of mica. Like so many others, this marl, aside from its content of carbonate of lime, owes its value to the greensand which it holds. The principal shell at Coffeeville is an oyster.—(*O. sellæformis*).

(*b.*) *Ordinary calcareous marls, white marls.*—At the Claiborne bluff the stratum, 15 to 20 feet in thickness, which has furnished all the beautifully preserved fossils which have made this locality so celebrated, is a mass of comminuted shells and quartz sands stained with iron. In this material the Claiborne fossils are imbedded. A sample of this marl from Mrs. Gibson's, a short distance below Claiborne, was analyzed. Its composition is given on p. 327, No. 135 of the table. The valve of this marl rests mainly upon its carbonate of lime. With from 47 to 50 per cent. of inert siliceous matter, it would hardly be profitable to carry it far, but it might be used with advantage in the vicinity.

This bed occurs below Claiborne in the bluff at or just above Gosport, at Rattlesnake Bluff, and nearly down to the mouth of Cedar creek, where it sinks below the water level.

On the Tombigbee it has been noticed at points a few miles above St. Stephens.

This shell stratum is one of the topmost of the Claiborne group proper. Immediately above it are laminated gray clays and fossiliferous yellowish sands containing greensand, and above these a thick bed of whitish, soft limestone, containing occasionally a few grains of greensand. This limestone is considered as belonging to the Jackson group of the Tertiary, and in its disintegration gives rise to the prairie soils of the lower lime-hills region, and is in many respects similar to the Cretaceous Rotten Limestone. Its composition may be seen from the subjoined analysis of soft, white limestone (No. 137) overlying the shell stratum at Claiborne (Jackson age.)

This, like the Rotten Limestone, is itself of the nature of a marl, and its action upon the soil is well shown in the prairie soils of the lime-hills.

In very many of the localities where this limestone occurs, crystals and large masses of gypsum are imbedded in the clays which result from its disintegration, and sometimes in such quantity that it might be profitably taken up for agricultural purposes. Nothing has, however, yet been done in this direction. The usually high percentage of sulphuric acid in the limestone, as well as in many of its derived soils, is probably due to the gypsum.

The uppermost division of the Tertiary in Alabama, the so-called Vicksburg group, is made up chiefly of white or light-colored limestones and marls, the most common rock being a soft, white limestone, containing orbitoides and other characteristic fossils. A sample of this rock from Clarke county, above Jackson (No. 146), has been analyzed, and its composition is given in the table relative to Tertiary marls.

This, as will be seen, is a tolerably pure limestone, and when burned would give a large yield of lime. Its potash and phosphoric acid, also, are rather above the average.

To recapitulate: The mineral fertilizers of the Alabama Tertiary formations are greensands, greensand marls, white

marls and limestones, and gypsum, which occur at the following horizons, viz :

1. Greensand and greensand marls on the Tombigbee river from Nanafalia down the river nearly to Barney's Upper landing. This may be traced across the country to the Alabama river, where it may be seen from Gullett's landing down the river to within five miles of Yellow Bluff. The same beds are exposed on Gravel Creek, in Wilcox county. Above Gullett's to Coal Bluff, many of the bluffs contain greensand.

2. A thin greensand marl bed occurs at Turner's ferry and at Tuscahoma on the Tombigbee. This bed has not been identified on the Alabama. It is of little importance agriculturally.

3. A greensand marl bed occurs at Lower Peach Tree and at Bell's landing on the Alabama river, but it has not been recognized yet on the Tombigbee. West of Lower Peach Tree this bed gives rise to the formation of Lime Hills soils which are to be seen in the direction of Choctaw Corner, nearly to the latter place. The Lime Hills north of Butler, in Choctaw county, are probably also in part at least due to this bed.

4. The greensand marls of Wood's Bluff, on the Tombigbee. This bed is seen in the town of Butler, in Choctaw county, and also across Clarke county and Wilcox to the Alabama river, where it crops out just below Bell's landing, at Johnson's Wood-yard. This marl and the preceding Bell's landing marl, are characterized by the presence of large boulder-like masses, produced by the induration of portions of the beds.

Beneath the indurated portion of the Wood's Bluff bed the softer marl has in many places been washed out and caves formed. This may be noticed around Butler, near Choctaw Corner, and just south of Lower Peach Tree.

5. Greensand marls at Coffeeville and at Claiborne, and at the latter place also, near the top of the bluff, the shell marl. These same beds are to be seen in many other localities, especially along the Alabama river below Claiborne.

6. Overlying the Claiborne shell beds the marly argillaceous limestone of Jackson age, which is known by its out-

crops and by the peculiar soils resulting from it, from the western limit of the State, through Washington and Clarke into Monroe and Conecuh, and thence into detached tracts to southeastern Alabama.

7. The white marls and limestones of the Vicksburg group, occurring in all the localities mentioned in the preceding paragraph, but much more widely distributed.

8. The gypsum beds which occur at many of the localities of the white limestones of the two preceding paragraphs. These gypsum marls have been noticed in Washington, and Clarke; in the latter county especially, near Gainestown.

I have given the localities of outcrops of these marls along our river banks in some detail, because I am convinced that they will some day be of much more importance to the farmers of the State than they are now. This is particularly true of the Nanafalia and Wood's Bluff marls. The rivers will naturally furnish the means of transport.

By connecting by a straight line the localities of the occurrence of these beds on the two rivers, it will be seen that the general direction of their line of outcrop is somewhat north of west and south of east across the country. Beyond and between these rivers their outcrops may be looked for through the country, along the continuation of this line, but a little north of it, since the beds rise slightly towards the northeast, and the line above indicated connects the points of outcrop at the water level.

The Tertiary formations in the eastern part of the State are more generally calcareous and less intermingled with lignitic strata than is the case westward, and they appear, also, to be more generally hidden by the superficial Drift deposits. A greensand marl has been observed at Kimmey's mill, south of Elba, in Coffee county; its exact geological position is not definitely determined, but it belongs in all probability to the Claiborne series.

Marls and limestones are exposed on the Chattahoochee river at intervals from below Eufaula down to the Florida line, but I am at present unable to give any details concerning them.

Analyses of Tertiary Marls.

	Greensand.	Greensand shell marls.					Ordinary marls.		
	Marengo County.	Marengo County.	Choctaw County.	Clarke County.		Monroe County.	Monroe County.	Claiborne County.	Clarke County.
	Greensand.	Greensand shell marl.	Hendrick's near Butler.	Near Choctaw Corner.	Greensand shell marl.	Marl, with greensand.	Claiborne shell marls.	Soft, white limestone.	White limestone.
	No. 128.	No. 127.	No. 126.	No. 130.	No. 138.	No. 136.	No. 135.	No. 137.	No. 146.
Insoluble matter	78.712	35.918	62.005	62 329	63 153	60.434	45.877	28.394	2 542
Soluble silica...	1.195 } 79.907	1.363 } 37 281	2.833 } 67.838	2.115 } 64.444	1.153 } 64 306	1.786 } 62.310	1.981 } 47 858	2.920 } 31.314	
Potash.....	0.635	2.254	1.026	0.457	0.372	0 633	0 331	0.502	0.347
Soda.....	0 087	0.346	0.085	0.252	0 259	0.222	0.498	0.777	0.132
Lime.....	0.859	24.164	13 757	16.866	14.491	15.390	26 514	34.952	47.779
Magnesia.....	0.284	1 617	0.616	0.705	0.594	0.856	0.065	0.743	6 002
Brown oxide of manganese...	0.011	0.079	0.029	Trace.	0 089	0 321	Trace.	0.156	0 653
Peroxide of iron	9.192	I2 324	4.286	2.083	2 149	3.867	2.332	1.798 }	3.123
Alumina.....	1.103	0.930	0.083	0.139	1.883	1.355	0.769	1 15[illegible] }	
Phosphoric acid	0 086	0.041	0.161	0.223	0.040	0.125	0.029	0.09[illegible]	0.305
Sulphuric acid..	0.051	0.310	0 106	0.054	0.164	0 117	0 070	0.29[illegible]	0.623
Carbonic acid...	Traces.	18.986	10.983	14.154	12.359	11.805	20.552	27.471	39.000
Water and organic matter..	5.713	0.728	1.393	1 366	3.102	2.832	1.554	2.207	4 162
Total.....	97.928	99.060	100.363	100.743	99.808	99.833	100.572	100.765	99 268

Of other naturally occurring materials which have been profitably used, either in compost heaps or directly upon the lands, there may be mentioned pond or marsh muck, which is specially rich in humus and also in certain mineral elements of plant-food. This substance is generally accessible in the State, and should, whenever practicable, be used in connection with the marls mentioned.

Professor Hilgard long since called attention to the value of the straw of the long-leaf pine as a manure, and his analyses show that it contains in considerable quantities the mineral ingredients necessary to plants. According to the same authority, the best manner of applying it, next to incorporating it with the manure pile, is to compost it with lime or some of the calcareous marls of which mention has been made, and, after it has become thoroughly decayed, then to spread it upon the land.

The following analysis of a specimen of muck from a swamp near the banks of Autauga creek, at Prattville, Autauga county, will show the general nature of this material. The swamp has a dense growth of magnolia, bay, laurel, short-leaf pine, sweet gum, sassafras, maple, elder, button-balls, white oak, swamp oak, dogwood, buckeye, *Rhus vernix*, etc. When cleared and drained such swamps are at first liable to suffer the drawbacks incident to an excess of humus, but after being a while in cultivation, and sand and loam become mixed with the humus, very productive soils result.

No. 2. *Black swamp muck* from the bottom of Autauga creek, at Prattville, Autauga county. A light-black pulverulent mass when dry.

SWAMP MUCK, AUTAUGA COUNTY.

	No. 2.
Insoluble matter	51.678
Soluble silica	
Potash	0.487
Soda	0.265
Lime	0.472
Magnesia	0.007
Brown oxide of manganese	Trace
Peroxide of iron	Trace
Alumina	1.362
Phosphoric acid	0.060
Sulphuric acid	0.296
Water and organic matter	44.574
Total	99.201
Hygroscopic moisture	18.47
absorbed at	20.5 C.°

The hygroscopic character of the humus is here well exhibited. The material contains a comparatively large percentage of lime and potash, but the phosphoric acid is rather deficient. This muck would improve the physical characters both of light sandy and of heavy clayey soils.

Table of Analyses of Alabama Soils and Subsoils.

Number.	Name.	Locality.	County.	Depth in inches.	Vegetation.	Insoluble residue.
	METAMORPHIC REGION.					
78	Red lands soil	6 miles north of Opelika	Lee	10	Red, Spanish, and post oaks, and some short-leaf pine.	68.710
79	Gray lands soil	do	do	8	do	79.170
107	Mica slate soil (graphitic)	4 miles north of Roanoke.	Randolph	8	Post, black, red and black-jack oaks; some pine and hickory.	77.354
103	Mica slate soil (garnetiferous)	S. 27, T. 19, R. 7 E	Clay	4	Black, post, red, and Spanish oaks; a few chestnuts.	66.174
	COOSA VALLEY REGION.					
70	Flatwoods soil	3 miles northeast of Ashville.	Saint Clair	10	Post oaks, short-leaf pine, and hickory.	70.650
71	Red valley soil	1½ miles south of Jacksonville.	Calhoun	12	Red, Spanish, and post oaks, hickory, and short-leaf pine.	80.520
76	do	Near Mrs. Walker Reynolds'.	Talladega	12	Red, white, Spanish, and post oaks, sweet and sour gums, and hickory.	64.070
45½	Red upland soil	Near Pratt's ferry.	Bibb	6–12	White, black, and post oaks, walnut, hickory, chestnut, mulberry, cedar, dogwood, and black gum.	81.480

67	Little Cahaba Valley soil	6 miles southwest of Springville.	Saint Clair	12	Red, black, and Spanish oaks, hickory, chestnut, and sweet gum.	73.433
69	Gray upland cherty soil	1 mile north of Ashville.	do.	10	Red and Spanish oaks, liriodendron, hickory, dogwood, and short-leaf pine.	83.440
123	Sandy brown-loam soil	3 miles west of Birmingham.	Jefferson	10	Red and willow oaks, sassafras, and grape-vines.	85.990
68	Red mountain soil	3 miles north of Springville.	Saint Clair	10	Large liriodendron, white oak, and chestnut.	81.560
111	Red lands soil	Dry valley, n'r Gaylesville.	Cherokee	8	Red, post, white, and Spanish oaks, hickory, persimmon, chestnut, black gum, sourwood, and dogwood.	78.725
	COAL MEASURES REGION.					
110	Upland soil	Sand mountain, near Valley Head.	DeKalb	10–20	Chiefly red oak, some black oak, hickory, dogwood, and chestnut.	86.350
	TENNESSEE VALLEY REGION.					
40	Barrens soil	Near Cluttsville	Madison	8	Post, black, red, Spanish, and black-jack oaks, scrub hickory, wild gooseberry, blackberry and huckleberry.	89.950
48	do	Near Huntsville	do	6	Scrubby post and black oaks, dogwood, and some hickory.	84.160
52	Gravelly soil	Limestone creek bottom.	do		Poplar, beech, sugar maple, sycamore, gum, walnut, red, white, and black oaks.	79.005
56	Gravelly river hills soil	Tennessee river, near Tuscumbia.	Colbert	4½	Red, white, and black-jack oaks, dogwood, white poplar, and scrub walnut.	79.320
38	Red lands soil	Near Cluttsville	Madison	11	Hickory, poplar, ash, chestnut, walnut, black, red, and white oaks, elm, cedar, black haw, and dogwood.	77.950

TABLE OF ANALYSES OF ALABAMA SOILS AND SUBSOILS—Continued.

Number.	Name.	Locality.	County.	Depth in Inches.	Vegetation.	Insoluble Residue.
	TENNESSEE VALLEY REGION—cont'd.					
34	Red lands soil	One mile east of Tuscumbia.	Colbert	10	Black-jack, post and red oaks, hickory and some cedar.	76.023
64	....do	Near Russellville, in Russell's valley.	Franklin	15	Red, black, white, post and black jack oaks, cedar, dogwood, chestnut, black walnut, cherry, and black locust.	75.360
36	Sandy loam soil	Little Mountains, near Tuscumbia.	Colbert	8	Chestnut, short-leaf pine, hickory, post-oak, small sourwood, wild pinks, and phlox.	93.630
	GRAVELLY PINE HILLS REGION.					
6	Upland sandy loam	Four miles east of Prattville.	Autauga	8	Short-leaf pine, red and post oaks, hickory, dogwood, black gum, chestnut, persimmon and mulberry.	89.100
57	Brown-loam soil	Near Mulberry	....do	.....	White post and red oaks, hickory, dogwood, black gum, and some pine.	91.510

60	Brown-loam subsoil of No. 57	....do	....do	6-12	....do	84.520
3	Upland pine woods soil	Near Prattville	....do	8	Long-leaf pine, hickory, red post and black-jack oaks; black gum.	94.170
4	Upland pine woods subsoil of No. 3.	....do	....do	12-18	Dogwood, persimmon, muscadine, buckeye, and sassafras.	88.060
61½	Pond lands soil (exhausted)	Near Mulberry	....do	6-12	Sweet gum mostly	78.630
9	Alabama river hummock soil	4 miles west of Montgomery.	....do	8	Red and white oaks, poplar, beech, sweet gum, elm, hickory, cherry, walnut, mulberry, sourwood, dogwood, thorny ash, grapes, and muscadines.	77.080
20	Warrior river hummock soil	Near Tuscaloosa	Tuscaloosa	6	Dense cane thicket	73.995
66	....do	....do	....do	14	Originally cane; now sweet gum and red oak.	69.900
21	Warrior river hummock soil (cultivated 20 years).	....do	....do	14	Dense cane thicket	73.339
22	Subsoil of Nos. 20, 21, and 66	....do	...do	14-24	....do	71.227
	OAK, HICKORY, AND LONG-LEAF PINE UPLANDS.					
140	Lime-hills soil	10 miles west of Lower Peach Tree.	Wilcox	8	Mostly beech, some hickory, short-leaf pine, oaks, ash, poplar, sweet and sour gum, holly, etc.	75.550
94	Sandy upland soil (cultivated)	Near Clayton	Barbour	1-12	Post oak, black-jack, hickory, dogwood, and short-leaf pine.	95.091
84	Upland sandy-loam soil	Near Lawrenceville	Henry	10	Red, Spanish and post oaks, black-jack, hickory, chestnut, gum, short-leaf pine, and some long moss.	95.115
18	Upland brown-loam soil	5 mil's southeast of Troy	Pike	8	Red oak; few short-leaf pines	91.965
19	Upland brown-loam subsoil	....do	....do	8-20	....do	90.960
92	Alabama river second-bottom soil	Near Lower Peach Tree	Wilcox	9	Sweet gum, short-leaf pine, poplar, Spanish, red and white oaks, haw and hackberry.	86.510

TABLE OF ANALYSES OF ALABAMA SOILS AND SUBSOILS—Coutinued.

Number.	Name.	Locality.	County.	Depth in inches.	Vegetation.	Insoluble Residue.
	CENTRAL PRAIRIE REGION.					
30	Black prairie soil	8 miles northeast of Livingston.	Sumter	10	Post, red, and black-jack oaks, cedar, and prairie white oak.	46.990
32	do	2 miles north of Livingston.	do	19	Post, red, and black-jack oaks, cedar, prairie white oak, walnut and cane.	81.745
16	do	4 miles from Union Springs.	Bullock	12	Post, and black oaks, short-leaf pine, haw, crab-apple, and some red oak.	57.831
77	Black prairie slough soil	8 miles south of Montgomery.	Montgomery	8	Hickory and white oak chiefly	25.188
17	Post-oak prairie soil	Near Union Springs	Bullock	12	Post oak, with long moss, hickory, short-leaf pine, and black-jacks.	71.366
11	Chunnenugga ridge soil	do	do	6	Chestnut, short-leaf pine, and red oak.	94.770
12	Chunnenugga ridge subsoil	do	do	6-20	do	96.810
13	Upland sandy-loam soil	2½ miles south of Union Springs.	do	6	Black and some post oaks, short-leaf pine, and huckleberry.	93.890
96	Low grounds soil	Cowikee creek	Barbour	8	Red, white, and post oaks, hickory, and short-leaf pine.	73.303

FLATWOODS REGION.					
25 Post-oak flatwoods soil	4 miles west of Livingston.	Sumter	10–48	Post oak chiefly, red oak, hickory, and short-leaf pine.	67.020
26 Post-oak flatwoods subsoil	do	do	10–48	do	79.662
98 Post-oak flatwoods clay	6 miles south of Linden	Marengo	10	Post oaks chiefly	72.746
LIME-HILLS REGION.					
139 Black-shell prairie soil	R. A. Long, S. 9, T. 8, R. 3 W.	Washington	8	Dogwood, white and black oaks, sweet gum, ash, short-leaf pine, etc.	21.655
90 Upland brown-loam soil	6 miles north of Gosport.	Clarke	10	Post, red, black, and Spanish oaks, short- and long-leaf pine, and some hickory.	87.753
91 Under clay or subsoil of No. 90	do	do	24–36	do	71.652
89 Murder creek second-bottom soil	2 miles west of Evergreen.	Conecuh	12	Sweet gum, magnolia, white and water oaks, and short-leaf pine.	89.870
LONG-LEAF PINE REGION.					
68 Upland pine-woods soil	13 miles east of Andalusia.	Covington	10	Long-leaf pine, post, Spanish, black-jack, and upland willow oaks, and some hickory.	90.815

TABLE OF ANALYSES OF ALABAMA SOILS AND SUBSOILS.—Continued (by the Numbers.)

Number.	Soluble silica.	Potash.	Soda.	Lime.	Magnesia.	Brown oxide of manganese.	Ferric oxide.	Alumina.	Phosphoric acid.	Sulphuric acid.	Carbonic acid.	Volatile matter.	Total.	Hygroscopic moist're	Temperature of absorption C.°)	Analyst.
78	3.830	0.350	0.119	0.043	0.050	0.100	10.740	9.237	0.170	0.080	.....	7.011	100.440	7.396	27.8	John B. Durrett.
79	3.256	0.268	0.067	0.167	0.130	0.093	3.144	5.120	0.229	0.043	.....	7.742	99.429	4.535	26.7	Do.
107	3.986	0.536	0.086	0.010	0.145	0.146	6.861	5.693	0.067	0.057	.....	4.772	99.713	4.612	7.2	Henry McCalley.
103	9.263	0.351	0.246	0.038	0.155	0.151	9.303	8.083	0.137	0.090	.....	5.706	99.697	5.910	6.1	Do.
70	8.933	0.277	0.078	0.159	0.478	0.079	6.528	7.497	0.075	0.013	.....	4.777	99.544	11.150	27.2	Chappell Cory.
71	3.941	0.290	0.062	0.112	0.260	0.056	5.011	5.722	0.126	0.056	.....	4.501	100.658	8.063	26.7	John B. Durrett.
76	7.647	0.339	0.111	0.091	0.143	0.137	7.157	11.229	0.170	0.010	.....	*8.298	99.408	19.400	24.4	Do.
45½	6.530	0.328	0.027	0.255	0.210	0.189	2.016	5.614	0.110	0.167	.....	3.587	100.513	4.528	28.3	Chappell Cory.

67	7.459	0.240	0.041	0.225	0.476	0.241	5.518	7.498	0.165	0.007	.....	4.719	100.022	9.525	7.2	Henry McCalley.
69	4.230	0.109	0.018	0.202	0.181	0.042	2.178	4.521	0.093	0.048	.....	5.301	100.363	8.528	26.7	Chappell Cory.
123	4.341	0.176	0.028	0.152	0.116	0.041	2.840	3.188	0.066	0.051	.....	2.522	99.511	7.835	24.4	Henry McCalley.
68	3.680	0.206	0.037	0.363	0.279	0.214	4.918	3.539	0.168	0.083	.....	4.830	99.877	9.799	27.2	Chappell Cory.
111	6.042	0.261	0.124	0.330	0.395	0.215	3.707	5.077	0.089	0.097	.....	*5.150	100.212	4.500	26.7	John B. Durrett.
110	4.352	0.230	0.141	0.068	0.154	0.070	1.443	6.324	0.073	0.062	.....	0.844	100.111	3.368	16.1	Henry McCalley.
40	2.292	0.255	0.064	0.064	0.035	0.150	1.695	3.292	0.100	0.178	.....	2.024	100.099	4.450	21.1	John B. Durrett.
48	4.560	0.116	0.025	0.041	0.159	0.041	2.705	4.597	0.054	0.045	.....	3.38	99.891	4.785	28.3	Chappell Cory.
52	6.023	0.270	0.161	0.182	0.224	0.239	2.871	4.834	0.209	0.010	.....	*5.758	99.786	6.881	9.4	Henry McCalley.
56	6.760	0.309	0.067	0.398	0.226	0.324	2.969	4.771	0.153	1.172	.....	4.458	99.927	5.371	28.3	Chappell Cory.
38	5.343	0.243	0.058	0.648	0.058	0.103	2.873	6.198	0.188	0.025	.....	*6.620	100.307	9.760	21.1	John B. Durrett.

*See table of humus determinations.

TABLE OF ANALYSES OF ALABAMA SOILS AND SUBSOILS—Continued (by the Number).

Number.	Soluble silica.	Potash.	Soda.	Lime.	Magnesia.	Brown oxide of manganese.	Ferric oxide.	Alumina.	Phosphoric acid.	Sulphuric acid.	Carbonic acid.	Volatile matter.	Total.	Hygroscopic mo'sture	Temperature of absorption (C.°).	Analyst.
34	8.995	0.276	0.133	0.267	0.381	0.218	5.230	5.691	0.151	0.020	.....	*1.794	99.179	8.840	7.8	Henry McCalley.
64	5.237	0.154	0.110	0.250	0.250	0.138	5.623	8.163	0.229	0.039	.....	4.100	99.653	6.140	26.7	John B. Durrett.
36	1.682	0.100	0.060	0.120	0.040	0.102	0.761	1.532	0.051	0.028	.....	2.055	100.161	1.560	25.6	Do.
6	2.840	0.073	0.018	0.060	0.061	0.122	1.577	4.350	0.077	0.034	.....	2.206	100.518	3.882	16.1	Chappell Cory.
57	1.960	0.115	0.004	0.557	0.140	0.027	1.527	0.943	0.042	0.013	.....	2.888	99.226	2.905	28.3	Do.

60	4.620	0.136	0.010	0.1[illegible]	6.172	0.071	2.422	6.078	0.078	0.074	.....	2.477	100.767	5.390	28.9	Do.
3	1.390	0.040	0.006	0.069	0.052	0.117	0.744	0.603	0.062	0.009	.....	2.807	100.069	1.916	23.9	Do.
4	3.380	0.111	0.029	0.047	0.139	0.125	1.572	4.320	0.077	0.002	.....	1.660	100.322	6.079	18.9	Do.
61½	6.045	0.193	0-094	0.019	0.198	0.079	0.810	7.951	0.076	0.132	.....	6.101	100.328	7.697	27.8	Do.
9	6.037	0.335	0.189	0.136	0.303	0.384	5.357	4.841	0.137	0.040	.....	*5.230	100.069	8.193	17.2	Henry McCalley.
20	6.518	0.252	0.052	0.468	0.429	0.006	4.395	5.182	0.274	0.071	.....	*8.893	100.535	18.811	17.2	R. H. Loughridge.
66	10.987	0.448	0.033	0.343	0.547	0.190	5.303	6.004	0.325	0.072	.....	6.311	100.463	8.707	29.4	Do.
21	8.777	0.383	0.052	0.314	0.502	0.041	4.590	5.288	0.214	0.072	.....	6.617	100.189	15.836	20.0	Do.
22	10.665	0.504	0.196	0.241	0.516	0.081	10.254	2.105	0.284	0.034	.....	4.490	100.597	14.016	16.7	Do.
140	1.134	0.174	.....	0.184	0.014	0.032	5.545	7.772	0.229	0.060	.....	8.922	99.616	17.067	10.5	Henry McCalley.
94	1.913	.....	0.007	0.010	0.056	0.131	0.603	1.386	0.025	0.001	.....	0.443	99.666	0.878	5.6	Do.
84	1.155	0.212	0.096	0.058	0.039	0.128	0.803	0.703	0.100	0.016	.....	2.009	100.434	1.225	23.3	John B. Durrett.
18	1.915	0.077	0.013	0.112	0.094	0.044	1.431	1.841	0.109	0.015	.....	2.137	99.753	2.590	19.4	R. H. Loughridge.
19	2.425	0.150	0.056	0.048	0.080	0.092	1.574	3.197	0.072	0.072	.....	1.532	100.258	2.826	18 3	John B. Durrett.
92	3.269	0.168	0.074	0.221	0.055	0.184	1.783	2.290	0.200	0.073	.....	4.510	99.337	5.916	22.2	Do.

*See table of humus determinations.

TABLE OF ANAYSES OF ALABAMA SOILS AND SUBSOILS—Continued (by the Number).

Number.	Soluble silica.	Potash.	Soda.	Lime.	Magnesia.	Brown oxide of manganese.	Ferric oxide.	Alumina.	Phosphoric acid.	Sulpuric acid.	Carbonic acid.	Volatile matter.	Total.	Hygroscopic moist're	Temperature of absorption, (C.°).	Analyst.
30	17.920	0.444	0.077	1.961	0.603	0.108	6.944	12.418	0.102	0.072	.....	*11.720	99.359	12.830	23.3	Chappell Corey.
32	2.346	0.205	0.076	0.960	0.061	0.192	3.843	6.168	0.318	0.152	.....	*4.075	100.141	6.042	26.7	John B. Durrett.
16	10.431	0.288	0.027	0.981	0.802	0.452	7.855	11.488	0.507	0.030	.....	8.036	98.728	14.489	16.7	Henry McCalley.
77	23.792	0.441	0.119	8.678	1.170	0.173	7.074	15.565	0.201	0.125	5.728	*11.589	99.843	19.992	7.2	Henry McCalley.
17	11.981	0.209	0.016	0.371	0.290	0.055	6.983	6.022	0.251	0.073	.....	*2.888	100.507	8.574	16.7	Henry McCalley.
11	0.486	0.156	0.069	0.081	0.069	0.156	0.706	0.733	0.101	0.057	.....	2.642	100.026	1.943	18.3	John B. Durrett.
12	1.060	0.165	0.107	0.110	0.035	0.065	0.490	9.867	0.113	0.065	.....	0.550	100.407	0.822	16.7	John B. Durrett.
13	1.878	0.209	0.134	0.076	0.021	0.065	0.883	1.260	0.058	0.083	.....	2.062	100.619	1.842	18.9	Henry McCalley.
96	11.592	0.245	0.060	0.280	0.351	0.113	2.666	5.489	0.113	0.013	.....	4.708	98.933	5.544	5.6	Henry McCalley.

25	10.050	0.295	0.125	0.198	0.610	0.115	6.543	10.198	0.212	0.027	.....	5.031	100.424	13.040	28.3	John B. Durrett.
26	5.031	0.223	0.059	0.359	0.596	0.073	7.711	3.308	0.072	0.026	.....	2.556	99.476	12.841	9.4	Henry McCalley.
98	8.926	0.416	0.112	0.080	0.691	0.106	12.406	2.473	0.103	0.061	.....	1.906	100.026	13.941	7.8	Do.
139	1.754	0.553	0.192	29.195	0.489	0.113	5.421	5.155	0.371	0.462	22.177	12.845	100.382	13.560	20.5	Do.
90	3.087	0.140	0.010	0.096	0.066	0.050	1.999	3.397	0.120	0.010	.....	3.080	99.808	2.895	23.3	John B. Durrett.
91	5.962	0.350	0.048	0.326	0.091	0.133	7.408	8.606	0.295	0.080	.....	5.187	100.138	14.380	22.2	Do.
89	1.592	0.140	0.016	0.094	0.018	0.078	2.385	3.355	0.122	0.005	.....	2.480	100.155	2.653	23.9	Do.
88	1.575	0.170	0.036	0.085	0.032	0.112	1.143	3.018	0.111	0.067	.....	2.772	99.936	2.558	23.3	Do.

*See table of humus determination.

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ANALYSES SHOWING THE COMPOSITION AT DIFFERENT DEPTHS OF THE SURFACE BEDS OF LOAM AND DRIFT IN THE SOUTHERN DIVISION.

Number.	Name.	Locality.	County.	Depth in Inches.	Vegetation.	Insoluble Residue.
115	Brown-loam soil	Near city of Tuscaloosa	Tuscaloosa	5		81.683
116	Subsoil of No. 115, deep red	do	do	5–18		84.777
117	Under subsoil of No. 115, deep red	do	do	18–42		91.493
118	Red sandy loam (under No. 117)	do	do	42–90		88.989
119	Red sandy loam, becoming yellowish below (under No. 118)	do	do	90–114		96.405
120	Yellowish coarse sand (below No. 119.)	do	do	114–168		98.370
122	Gray clay, specked with red	do	do	Bottom of gully		81.837

ANALYSES SHOWING THE COMPOSITION AT DIFFERENT DEPTHS OF THE SURFACE BEDS OF LOAM AND DRIFT IN THE SOUTHERN DIVISION—Continued (by the Number).

Number.	Soluble silica.	Potash.	Soda.	Lime.	Magnesia.	Brown oxide of manganese.	Ferric oxide.	Alumina.	Phosphoric acid.	Sulphuric acid.	Carbonic acid.	Volatile matter.	Total.	Hygroscopic moist're	Temperature of absorption C.°)	Analyst.
115	0.465	0.255	0.175	0.140	0.097	0.102	4.184	7.081	0.090	0.025	.....	5.425	99.722	6.305	18.0	Daniel W. Langdon, jr.
116	0.656	0.205	0.175	0.065	0.100	0.099	4.903	6.278	0.086	0.083	.....	2.288	99.715	7.275	18.0	Do.
117	0.066	0.150	0.140	0.071	0.005	0.066	2.495	3.466	0.007	0.071	.....	1.987	100.017	5.647	19.0	Do.
118	1.827	0.139	0.135	0.045	0.004	0.061	2.592	3.998	0.007	0.066	.....	1.791	99.654	4.103	18.0	Do.
119	0.687	0.005	0.004	0.006	0.002	0,003	1.910	0.786	0.003	0.004	.....	0.841	100.656	3.996	18.0	Do.
120	0.086	0.005	0.003	0.004	0.001	0.002	0.717	0.454	0.001	0.004	.....	0.752	100.399	0.290	19.0	Do.
122	0.256	0.256	0.197	0.341	0.194	0.010	0.576	11.314	0.001	0.150	.....	5.140	100.272	.....	.....	Do.

TABLE SHOWING HUMUS AND AVAILABLE INORGANIC MATTER IN SOILS (PERCENTAGES ARE REFERRED TO SOILS).

	No. 76.	No. 111.	No. 52.	No. 38.	No. 34.	No. 9.	No. 20.	No. 30.	No. 32.	No. 77.	No. 17.
Humus	0.984	1.365	1.974	2.242	0.700	1.047	2.310	2.830	2.000	2.460	0.718
Available inorganic matter	.....	1.061	0.860	1.551	0.956	0.862	1.255	0.740	1.430	1.874	2.426
Available phosphoric acid	0.020	0.029	0.073	0.109	0.020	0.058	0.112	0.060	0.108	0.037	0.015

ANALYSES SHOWING COMPOSITION OF GREENSANDS, GREENSAND MARLS, SHELL MARLS, AND LIMESTONES OF THE CRETACEOUS AND TERTIARY FORMATIONS OF ALABAMA.

Number.	Name.	Locality.	County.
132	Greenish micaceous sands (Cretaceous)	Pleasant Ridge	Greene
145	Greensand marl (Cretaceous)	Epes' Station	Sumter
128	Greensand (Tertiary)	Double creek	Marengo
127	Greensand shell marl (Tertiary)	Nanafalia landing	do
126	....do	Hendricks', near Butler	Choctaw
130	....do	Near Choctaw Corner	Clarke
138	....do	Coffeeville landing	do
136	Marl, with greensand (Tertiary)	15 feet above water-level at Claiborne	Monroe
135	Claiborne shell stratum (Tertiary)	Mrs. Gibson's, Claiborne	do
137	Soft, white limestone (Tertiary, Jackson)	Overlying shell stratum at Claiborne	do
146	White limestone (Tertiary, Vicksburg)	North of Jackson	Clarke
2	Black swamp muck	Prattville	Autauga

ANALYSES SHOWING COMPOSITION OF GREENSANDS, GREENSAND MARLS, SHELL MARLS, AND LIMESTONES OF THE CRETACEOUS AND TERTIARY FORMATIONS OF ALABAMA—Contiued (by the Number).

Number.	Insoluble residue.	Soluble silica.	Potash.	Soda.	Lime.	Magnesia.	Brown oxide of manganese.	Ferric oxide.	Alumina.	Phosphoric acid.	Sulphuric acid.	Carbonic acid.	Volatile matter.	Total.
132	76.734	1.162	0.115	0.890	0.899	0.592	0.170	8.457	0.091	0.051	0.789	.....	10.216	99.674
145	57.617	1.778	1.439	0.118	8.922	0.193	0.101	13.988	2.161	0.143	0.160	10.628	2.260	99.508
128	78.712	1.195	0.635	0.087	0.859	0.284	0.011	9.192	1.103	0.086	0.051	traces.	5.713	97.928
127	35.918	1.363	2.254	0.346	24.164	1.617	0.079	12.324	0.930	0.041	0.310	18.986	0.728	99.060
126	65.005	2.833	1.026	0.085	13.757	0.616	0.029	4.286	0.083	0.161	0.106	10.983	1.393	100.363
130	62.329	2.115	0.457	0.252	16.866	0.705	trace.	2.083	0.139	0.223	0.054	14.154	1.366	100.743
138	63.153	1.153	0.372	0.259	14.491	0.594	0.089	2.149	1.883	0.040	0.164	12.359	3.102	99.808
136	60.434	1.876	0.633	0.222	15.390	0.856	0.321	3.867	1.355	0.125	0.117	11.805	2.832	99.833
135	45.877	1.981	0.331	0.498	26.514	0.065	trace.	2.332	0.769	0.029	0.070	20.552	1.554	00.572
137	28.394	2.920	0.502	0.077	34.952	0.743	0.156	1.798	1.159	0.096	0.290	27.471	2.207	100.765
146	2.542		0.347	0.132	47.779	0.602	0.653	3.123		0.305	0.623	39.000	4.162	99.268
2	51.678		0.487	0.265	0.472	0.007	trace.	trace.	1.362	0.060	0.296	.....	44.574	*99.001

* Hygroscopic moisture, 18.47 ; absorbed at 20.5 C.°

No. 146 was analyzed by T. W. Palmer ; all the others by Henry McCalley.

SECTION III.

AGRICULTURAL DESCRIPTIONS OF THE COUNTIES OF ALABAMA.

The counties are here grouped under the heads of the several agricultural regions, previously described, to which each predominantly belongs, or, in some cases, under that to which it is popoularly assigned. Each county is described as a whole. When its territory is covered in part by several adjacent soil-regions, its name will be found under each of the several regional heads in which it is concerned, with a reference to the one under which it is actually described. In the lists of counties placed at the head of each group the names of those described elsewhere are marked with an asterisk (*), and the reference to the head under which these are described will be found in its place, in the order of the list, in the text itself.

The regional groups of counties are placed in the same order as that in which the regional descriptions themselves are given.

The statements of areas, of woodland, prairie, etc., refer to the original state of things, irrespective of tilled or otherwise improved lands.

Appended to the description of each county from which a report or reports have been received, is an abstract of the main points of such reports, so far as they refer to natural features, production, and communication. Those portions of the reports referring to agricultural and commercial practice are (in condensed form) placed in a separate division (Section IV), following that of the county descriptions.

In making the abstracts of these reports it has been necessary, in most cases, to change somewhat the language of the reporter while preserving the sense. In some cases statements palpably incorrect or overdrawn have been altogether omitted, while sometimes explanatory words have been added, placed in parentheses.

METAMORPHIC REGION.

The following counties lie partly or wholly within the Metamorphic region: Cleburne, Randolph, Chambers, Lee, Tallapoosa, Clay, Coosa, Talladega,* Chilton,* and Macon.*

CLEBURNE.

Population: 10,976.—White, 10,308; colored, 668.

Area: 540 square miles.—Woodland, all. Metamorphic, 400 square miles; Coosa Valley, 140 square miles.

Tilled land: 51,428 acres.—Area planted in cotton, 9,156 acres; in corn, 21,552 acres; in oats, 5,672 acres; in wheat, 7.504 acres; in tobacco, 85 acres; in sweet potatoes, 221 acres.

Cotton production: 3,600 bales; average cotton product per acre, 0.39 bale, 555 pounds seed-cotton, or 185 pounds cotton lint.

The northern part of Cleburne county consists of high and rugged mountains of sandstone and subordinated ridges of flint or chert, alternating with valleys or inclosing coves of red or yellow fertile lands. This part of the county is of the same nature as adjoining portions of Cherokee and Calhoun. The red soils are based on the magnesian limestones of the country, and the broken and ridgy lands have a soil of gray or light colors. All these valley lands contain more or less of angular flinty gravel in both soil and subsoil. The timber on the flint ridges is in many cases prevalently long-leaf pine; upon the sandstone mountain the oaks and short-leaf pine predominate as a rule. The mountain lands are generally uncultivated; the ridge lands also, especially where there is much of the chert flor int in large masses. Upon the slopes, however, there are often very good gravelly lands, with yellow subsoil under cultivation. The rest of the county is made up of slaty or crystalline rocks, and the soils derived from them are of two principal classes, viz: the red and the gray lands. In addition to these there are the sandy lands of the creek and river bottoms. In crossing the county from northwest to southeast one goes across

the belts of different rocks and of the different classes of soils which are derived from them.

The western boundary of the county, as far north as township 14, is made by a mountain range of crystalline slates and conglomerate. In township 14 this range turns eastward, and its prolongation in Georgia is known as Dug-Down mountain. On this mountain, which is several miles wide, there is very little level land, and, as the rocks which form the mountain furnish soils that are sandy and clayey, and in the main not very fertile, this part of the county is comparatively thinly settled and little cultivated. Across the mountain we descend into the valley of the Tallapoosa river, and of Cane creek, its western fork. The width of this valley varies, being at Ross' ford about one mile. The bottom lands are generally best suited to corn and other grain, though some are cultivated in cotton. The valley of the Tallapoosa is separated from that in which Arbacoochee is situated by a ridge of some 200 or 250 feet in height, with little level land and few settlements. The valley of Arbacoochee is drained by a small stream called Dying creek, and in this valley many of the characteristic features of the valley lands of this region are well shown. The rocks which underlie these valley lands are comparatively easily disintegrated by the atmospheric agencies, and near the surface they have been weathered into reddish and yellowish clays, which retain the bedding or stratification of the original rocks. These rocks consist in part of thin beds or sheets of quartz which resist decay, and as the more yielding materials are worn away the quartz fragments cover the ground. The soil is a dark colored loam, underlaid with a red clay, which is the result of the removal and redeposition of the underlying "slates," which, in turn, are the stratified clays resulting from the decay, in place, of the original rocks as before stated. The valley lands are rolling and gently undulating, and comprise many very fair farms.

The region about Arbacoochee is best known as a great center of gold-mining operations thirty years ago. Southeast of Arbacoochee for five or six miles there are hilly or mountainous lands, with mica slates near the surface, thinly covered with soil; in consequence there is but little cultiva-

tion. These harder slates alternate with others containing a good deal of hornblende (an iron bearing mineral), and as the hornblendic rocks disintegrate quite readily, their positions are usually marked by valley-like depressions with a red or yellow clayey soil, which supports a growth of white, red, and Spanish oaks, sour gum, walnut, and hickory. Pennyroyal, a lime-loving plant, is found in most of the fence corners where this soil predominates. The red soils of this kind are considered best for corn and other grains, but they are not so good for cotton. In good seasons they are quite productive, but are inclined to be drouthy.

The lower part of this county is characterized by the predominance of red lands, a belt of which, five or six miles, in width, crosses the county almost east and west, near its southern boundary. The soil is yellowish-brown loam, which, for most crops, is very productive. Throughout the county the gray soils greatly predominate, the red soils, with which they alternate, being usually in comparatively narrow belts. As showing the average composition of the red soils, see analysis of a soil of this kind from Lee county (page 187). The gray lands are of widely different grades of fertility, according to the nature of the rocks from which they have been derived. The best of the gray soils are derived from a granitic rock, and are frequently found closely associated with the red soils just spoken of. Such soils rank in fertility among the best in the county, but they are not the most widely distributed. Gray soils derived from mica and clay slates, make up the greater part of the lands of this region, and are found both in the uplands and in the lowlands, being in the latter position usually somewhat more sandy. The gray lands have a growth of the various species of oaks, and with these pines, where the sandy material predominates. The average composition of the gray soil of the better quality may be seen from an analysis of a gray soil collected near Opelika, in Lee county (see page 187.)

The cotton production of Cleburne county is small, which is partly due to the fact that there is no railroad or navigable stream. Lying, as it does, along the northwestern border of the metamorphic regions, only a small proportion of its soils can be rated as first class.

ABSTRACT OF THE REPORTS OF JOHN R. MOTIS, OF EDWARDSVILLE, AND OF JAMES H. BELL AND DAVID V. CRIDER, OF ARBACOOCHEE.

(These reports refer to the region drained by Crane creek and the main fork of the Tallapoosa river.)

In general, the uplands away from the streams are rather poor, and most of the farming lands are found in the vicinity of the river and the creeks. The low bottom lands are not best suited to cotton, as the plant is late in getting started and liable to injury from early frosts. For this reason the uplands, though not so fertile, are preferred. Notwithstanding these objections to the bottom lands, they are much cultivated in cotton, on account of the generally inferior quality of the uplands. The bottom growth is a mixture of oaks, hickory, walnut, gum, etc. The top soil is usually a sandy loam of gray and yellowish to dark colors, eight to ten inches in thickness, with a subsoil in general somewhat heavier, and of gray to yellow and reddish colors, according to locality. The underlying rock also varies with the locality, being, however, some kind of slate rock at depths of from six to ten feet. These soils, while best suited to corn, are yet, in places, well adapted to cotton. The other soil varieties are the red lands, which are best for grain crops, and the pine lands, with gray gravelly soils.

The chief crops are cotton, corn, wheat, oats, etc., but the soil is for the most part best adapted to corn, cotton, and oats. From one-third to one-half of the cultivated land is in cotton, which usually grows to the height of two and a half to four feet. After five years' culture (unmanured) the yield decreases about one-half. Very little land is turned out; and if reclaimed, it produces well for a few years.

RANDOLPH.

Population: 16,575.—White, 13,155; colored, 3,420.

Area: 610 square miles.—Woodland, all. All Metamorphic.

Tilled land: 81,426 acres.—Area planted in cotton, 23,177 acres; in corn, 29,595 acres; in oats, 4,850 acres; in wheat, 10,156 acres; in tobacco, 44 acres; in sweet potatoes, 433 acres.

Cotton production: 7,475 bales; average cotton product per acre, 0.32 bale, 456 pounds of seed cotton, or 152 pounds cotton lint.

In Randolph county, as in other counties of this region, the rocks and their derived soils are disposed in belts which have a general northeastern and southwestern direction, and in crossing the county from northwest to southeast the relations of these belts may best be made out. The hornblendic rocks, which yield reddish and tolerably fertile soils and give rise to gently undulating topography, occupy the

northwestern corner of the county, and another belt of a very similar nature is found in the southeastern portion, while the greater part of the intervening country is made up of mica and clay slates. The mica slates extend as far as the Little Tallapoosa river, beyond which comes a belt of the clay slates to Wedowee, and then a repetition of the mica slates as far as the line passing northeastward through Louina. The country made by the mica slates is in general rather broken and the soils somewhat sandy, and is not very fertile. The timber consists of the upland oaks and hickories, with long-leaf pines, the latter becoming in many places the prevailing tree. The clay slates give generally a stiffer and more fertile soil than the beds just mentioned, and the usual timber is oak and hickory, with very little pine.

Below Wedowee, to the limit above named, while the mica slates are most prominent among the strata, they alternate with the gneisses, which, in many places, take the characters of granites. The soils derived from this class of rocks are about the best in the county, and, as showing their average composition, the reader is referred to the analysis of gray granitic soil from Lee county, given on page 187. The mica-slate soils are well represented in the analysis of a soil of that kind collected in Clay county (see page 189). South of Louina to the line of Chambers county the soils are mostly red, derived from the hornblendic rocks alluded to before. The subsoils are also red, and rest on yellowish and reddish stratified clays, which are nothing more than the decayed slates of the country.

In the southeastern part of the county, from Roanoke to the line of Chambers, the soils are sandy, and deep beds of white sand remind one of the southern counties of the State. The color of this soil is gray to whitish, and the timber is chiefly long-leaf pine, with black-jack and the other oaks which are so commonly found in the piny woods. The only rocks which are to be seen in this pine region are sandstones and siliceous rocks, and in many places the fragments of quartz-seams cover the ground. This is usually the case, however, near the edge of the pine region.

The drainage of Randolph county falls into two systems,

the greater part being into the Tallapoosa river, a small area in the southeastern corner belonging to the Chattahoochee.

In its relations to cotton production Randolph stands between Cleburne and Clay on the one hand and Chambers on the other. It is remote from a market, and its soils are not the best suited to cotton, except in certain sections, which are mostly in the lower part of the county.

ABSTRACT OF THE REPORT OF JAMES H. RADNEY, OF ROANOKE.

(The region referred to lies within the drainage area of High Pine and Corn House creeks, tributaries of the Tallapoosa.)

The uplands are preferred for cotton culture, since in the lowland the plant is liable to be late, to take the rust, and to be killed by early frosts before full maturity. The two chief varieties of soil are those of the gray and red uplands, which make at least three-fourths of the cultivated lands of the region described. For cotton culture the slopes facing the south or southeast are preferred to other localities. The timber upon these uplands consists of pines, oaks, and hickories, the preponderance of one or the other of these trees depending on the quality of the soil. The top soil varies from light sandy and gravelly to a rather heavy, clayey loam of gray to brown or red colors, resting on a subsoil of yellow or red clay (sometimes very sandy). The underlying material is a soft, rotten-slate chalk, which is found at a depth of from four to eight feet. Of less importance in the cultivation of cotton, but important for corn and other grain crops, are the light sandy-bottom soils. These have a natural growth of white oaks, beech, and poplar.

The chief crops are corn and cotton; the former on lowlands, the latter on uplands. About one-half of the land is planted in cotton, which usually attains a height of from two to six feet, but is most productive at three or four feet. One-tenth of the land originally in cultivation is turned out, but when such land is treated with manure it produces well.

CHAMBERS.

Population: 23,440.—White, 11,364; colored, 12,076.

Area: 610 square miles.—Woodland, all. All Metamorphic.

Tilled lands: 149,283 acres.—Area planted in cotton, 70,934 acres; in corn, 49,306 acres; in oats, 9,258 acres; in wheat, 11,520 acres; in tobacco, 39 acres; in sugar-cane, 211 acres; in sweet potatoes, 1,038 acres.

Cotton production: 19,476 bales; average cotton product per acre, 0.27 bale, 384 pounds seed cotton, or 128 pounds cotton lint.

The water-shed between the Chattahoochee and the Tallapoosa runs nearly north and south through Chambers county. The bedded rocks which form the substratum of this county all have the general direction of northeast and southwest, except in the southeastern corner, where their arrangement is quite irregular; and on this account the soils of different kinds are in belts which pass through the county from northeast to southwest. The soils are essentially of two kinds, the red and the gray, and a northeast and southwest line through the county a few miles northwest of LaFayette would be about the dividing line between these two varieties. Toward the northwest the soils would be mostly gray, and toward the southeast mostly red; but in both divisions the predominant soil variety is marked by many belts and patches of the other varieties.

In the northern and northwestern parts of Chambers county, where the gray soils prevail, the country is rolling or gently undulating, and the timber consists of species of upland oaks, with long-leaf pine, the latter becoming the principal tree in some localities where the soil is sandy. In the extreme northwest the underlying rocks are slates, which have been thoroughly disintegrated in place, and have been converted into stratified clays of a yellowish color, with a top covering of yellow or brown loam, constituting the soil and subsoil. These slates are always interbedded with seams of quartz, the fragments of which in some places completely cover the ground. The soils are of moderate fertility. Near Milltown, the granite appears often at the surface as large areas of bare rock. The granitic soils are among the best in the county, and their average composition may be seen by reference to an analysis under Lee county, given on page 187.

The red soils are characteristic over more than half of the lower part of Chambers county, and the hornblendic rocks, from which they have been derived, are usually worn down by denudation rather uniformly, producing an undulating surface. The timber is mostly of oaks, and nowhere can more luxuriant groves of red, Spanish, white and post oaks be seen than upon the rolling red lands of Chambers. These red lands, as stated elsewhere, are better suited to

the production of grain crops than of cotton, though a considerable proportion of the latter crop is always planted. The red lands have from the first been selected by the farmers, and it is rarely that any large areas can now be seen that have not been cleared and put in cultivation. Most of the handsome residences of the prosperous planters of *ante-bellum* days are situated in the midst of these lands, and are surrounded with the splendid oak groves alluded to.

Chambers county forms a part of the great Central cotton belt of the State, and its soils, particularly those in the lower townships, are well suited to the production of cotton. Such are the red and gray gneissic soils, of which mention has been made before. From LaFayette to the southern limit of the county the greater part of the land is in cultivation, and cotton forms nearly one-half of the crops cultivated. The greater part of the cotton crop is sold to merchants at LaFayette, Opelika, and West Point.

LEE.

Population: 27,262.—White, 12,217; colored, 15,045.

Area: 610 square miles.—Woodland, all. All Metamorphic; but the rocks over about 250 square miles in the southern part of the county are covered with Stratified Drift, which yields the soils and subsoils.

Tilled land: 122,875 acres.—Area planted in cotton, 51,889 acres; in corn, 30,137 acres; in oats, 11,918 acres; in wheat, 8,697 acres; in rice, 10 acres; in tobacco, 11 acres; in sugar-cane, 208 acres; in sweet potatoes, 925 acres.

Cotton production: 13,189 bales; average cotton product per acre, 0.25 bale, 357 pounds seed-cotton, or 119 pounds cotton lint.

Lee county, though formed by the strata of the Metamorphic series, has these rocks almost entirely covered over the southern half by the beds of Stratified Drift. In the northern half of the county, the metamorphic or crystalline rocks are directly concerned in the formation of the soils, and it is necessary to a proper understanding of the kinds and distribution of these soils first to give a short account of the rocks which yield them. The greater part of the county

is made up of gneisses or crystalline sedimentary rocks composed of three minerals, quartz, feldspar, and mica, in varying proportions, by reason of which variations in the quality of the rock and of the soil derived from it are brought about. Further variations are due to the circumstance that hornblende may partly or wholly replace the mica. The hornblendic rocks, in decomposing, give rise to soils which are deeply colored by red iron. In many places the feldspar is deficient, sometimes wanting, and the rock passes into mica slate, with a corresponding change for the worse in the soil produced from it.

In the southern half of the county, or rather traversing it in a northeastern and southwestern direction near its center, is a belt of limestone (magnesian) associated with beds of micaceous sandstone. These, especially the limestone, are generally covered with beds of Drift, and therefore very slightly affect the soils; the sandstone, however, forms some hills with sterile soil in the southwestern part of the county, near the line of Macon. Aside from the Drift soils, therefore, the arable lands of Lee county may be classed as gray, red, and sandy, the gray soils, derived from the gneissic rocks, being most abundant, forming about three-fourths of the land, and varying considerably in fertility, as might be inferred from what has been said before concerning the rocks which furnish them (see analysis of an average soil of this kind from near Opelika, page 189). The red soils are next in abundance, as well as in importance in cotton cultivation, and an analysis of one of these, also from near Opelika, has been presented on page 189. The sandy soils are of least importance here, as in other places. The Drift soils vary, as usual, between heavy clayey loams and light sandy loams, and as they are similar to the Drift soils elsewhere, an enumeration and description of them need not be repeated here.

Lee county, like Chambers, is one of the great Central cotton counties. The soils best suited to the cotton-plant are the red and gray gneissic soils in the north, and the loam soils of the Drift in the south, the latter characteristic of the Gravelly hills region.

ABSTRACT OF THE REPORTS OF MR. JOHN T. HARRIS, OF OPELIKA, AND MR. C. H. M'CULLOH, OF BEULAH.

(These reports relate to the lands within the drainage areas of Osanippa and Hallawoka creeks and the Chattahoochee river.)

The soils, in the order of their relative abundance and importance in the cultivation of cotton, are the gray lands, the red lands, and the sandy lands. The gray soils constitute from a half to three-fourths of the arable lands of the county, the natural timber of which is short-leaf pine, all varieties of upland oaks, except the black-jack, which is comparatively scarce, hickory and poplar; in swamps, ash, maple, and gum. This soil is a light sandy loam of prevailing gray color, passing occasionally into buff and yellowish. The average thickness to change of color is from three to six inches. The subsoil is generally a little heavier than the surface soil, and is sometimes a yellowish or reddish clay, containing angular fragments of quartz. This subsoil is underlaid with the more or less decayed gneiss, or mica slate, from which it has been derived, and it is a not an uncommon thing to see the subsoil passing by insensible gradations through the stratified clays into the unchanged rock. The red lands make up from a very small proportion to nearly one-half of the lands, but the red and the gray, in some sections, alternate with each other in such a way that it is impossible to map out their distinct areas, except with a vast amount of close and accurate surveying. This soil is a light clayey loam, usually of brown, mahogony, and red colors, from five to eight inches thick to a change of color. The subsoil in consistence is not much heavier than the soil, though perhaps commonly of a slightly darker red color. Like the gray soil, this also contains the angular quartz fragments. The red soils are considered best suited to corn and other grains, though cotton forms on this, as well as on the gray soil, two-hirds to three-fourths of the cultivated crop. The sandy soils in the neighborhood reported upon are of little extent, but are very generally planted in cotton.

The above-named lands are easy to cultivate in wet and dry seasons, being well drained, but rather early and warm. The crops are cotton, corn, wheat, oats, and sweet potatoes. The gray soil is perhaps best adapted to cotton, and the red to corn and grain, but all the other crops generally succeed. From two-thirds to three-fourths of the whole area is planted in cotton, which varies in height from two to four feet, and is most productive when say three feet high. From one-fourth to one-sixth of the land originally in cultivation is now turned out, but by the use of fertilizers, such lands can be made to yield nearly or quite as much as when fresh.

TALLAPOOSA.

Population: 23,401.—White, 16,108; colored, 7,293.

Area: 810 square miles.—Woodland, all. Metamorphic, all; but about 100 square miles in the lower part of the county are covered with Stratified Drift.

Tilled land: 143,175 acres.—Area planted in cotton, 41,200 acres; in corn, 41,415 acres; in oats, 9,106 acres; in wheat,

14,572 acres; in tobacco, 21 acres; in sugar-cane, 41 acres; in sweet potatoes, 408 acres.

Cotton production: 14,161 bales; average cotton product per acre, 0.34 bale, 486 pounds seed-cotton, or 162 pounds cotton lint.

There are no striking topographical features to be noticed in Tallapoosa county. The drainage is all into the Tallapoosa and the three principal tributaries on the east, Sandy, Blue, and Sougahatchee creeks, which have their sources near the water-shed between the Chattahoochee and the Tallapoosa, a ridge traversing Chambers and Lee counties. All the bedded rocks of the county are crystalline or metamorphic, and, like all strata of the region of crystalline rocks, lie in sheets whose outcropping edges have the prevailing direction of northeast and southwest. The soils derived from these rocks are disposed in parallel belts having the same general direction. Bearing these things in mind, a description of the agricultural features of the county may best be given by naming the soil belts which are crossed in succession in passing through the county from northwest to southeast.

As to color, there are two varieties of soils: the red and the gray; but the latter vary very greatly in respect to their fertility, as well as in respect to the rocks from which they have been derived, and in some cases, when derived from granitic rocks, rank among the best in the county. These have commonly a subsoil which is more or less reddish or yellowish in color. The characteristic timber consists of the species of upland oaks, with some short-leaf pine. When based upon siliceous rocks and mica slates, especially when these are very siliceous, the gray soils are sandy and have a light-colored sandy subsoil, and then the prevailing timber is the long-leaf pine, with its associates, black-jack and post oaks. Such soils stand low in the scale of fertility. Similarly, there are grades in the fertility of the red and yellow soils. Those derived from hornblendic rocks are of a deep-red color, are rich and strong, and are timbered with the upland oaks—white, red, Spanish, and post. Upon these the long-leaf pine is seldom seen. As has been before stated, the red soils are best suited to the grain crops. An-

other kind of reddish soil, derived from certain varieties of mica slates and clay slates, has a prevailing timber of small oaks, with very few pines. In addition to the above-named soil varieties there are the usual bottom soils, which are in their nature dependent upon the surrounding uplands from which they have been washed. As a rule, the bottom soils are rather sandy, and in most cases are more fertile than the surrounding uplands.

As to distribution, in the northwestern corner of the county there is a small area in which the rocks are thick-bedded and approach granite in structure, and throughout this region the soils are red and gray, with red subsoils, and of rather exceptional fertility. Thence southeastward to Dadeville the country is made up of belts of light-gray sandy soils, timbered with long-leaf pines, alternating with light-yellowish sandy and loamy soils based on mica and clay slates, and supporting mostly oak growth. Subordinated to these are areas of red soils, with red or yellow subsoils, but these do not become prominent till Dadeville is passed. Between Dudleyville and Dadeville there is much of this undulating country with oak and hickory growth, but a little northwest of the direct line between the two places runs a belt of long-leaf pine land with sandy soil, and in places, especially near the Tallapoosa river, in the vicinity of the line of Chambers county, there are deep beds of white sand, much resembling some parts of the State where the Stratified Drift forms the surface.

Below Dadeville, to the southeastern limit of the county, the red and gray soils, with red or yellow subsoils, prevail, with here and there a belt of sandy pine land. The red and gray colors are about equally prevalent, and the soils about equal in fertility where both have the red subsoil. The agricultural characters of these two varieties are well shown in the abstract given below.

South of the Sougahatchee creek to the lower end of the county the sands, pebbles, and loams of the Stratified Drift overlie all the country rocks, hiding them completely from view, except in the vicinity of streams. In this part of the county, therefore, these superficial beds are alone involved in the formation of the soils. In some parts of the region

thus covered with the Drift there are beds of steatite, which will probably some day be of value. At Tallahassee the rocks cause cascades in the Tallapoosa river, and these have been utilized to furnish the power for one of the largest cotton factories in the State.

The chief cotton soils of Tallapoosa county are the red and gray gneissic soils and some of the lowlands of the river and creeks, and, in addition to these, the loams of the Drift by which the southern portion of the county is covered. A large proportion of the cotton crop is produced in the southern sections, where there is a prevalence of the above-named soils. Toward the north and northwest the slaty soils are much less suited to the crop.

ABSTRACT OF THE REPORTS OF D. A. G. ROSS, OF CAMP HILL, DANIEL TAYLOR, OF NEW SITE, AND JAMES M. PEARSON, OF DADEVILLE.

(*The second refers to the region drained by Emuckfau creek; the other two to the region of Sandy creek.*)

About New Site the soils are mostly gray, with subsoils varying from a sandy clay to a rather stiff red clay. In the other localities the red and the gray soils are about equal in extent, the gray being, if anything, rather more abundant. The uplands are preferred for cotton, for the reason that in the lowlands the plant is likely to be late, and therefore to be killed by frost before maturity. Under all circumstances the use of ammoniated manures is recommended, as these cause the plant to mature early and escape the danger from frosts. The soils described are—

First. Gray soil. This soil makes from one-half to two-thirds of the cultivated lands of the county, and varies in fertility and in other respects with the varying quality of the subsoil, which is sometimes a red clay and sometimes sand or gravel. The timber in the first case is a mixture of oaks and hickories, poplar, ash, etc. When the subsoil is light, the long-leaf pine becomes a characteristic growth. The average thickness of the top soil is six inches. The underlying granitic rock, from which both soil and subsoil are derived, is found at varying depths from the surface.

Second. The red soils. These make from one-third to one-half of the cultivated lands of the county, being more widely spread over the southern half. The natural timber consists of oaks and hickories, with very few pines. The top soil is a fine sandy to clayey loam, five or six inches in thickness, with a subsoil of red clay, and is usually of a darker shade (brown) than the subsoil. The subsoil, as a rule, contains fragments of quartz or flint, the underlying original rock being found at varying depths. Of these two soil varieties the gray is best suited to the cotton crop, the red to grains. On the light sandy gray soils the principal oak, which is associated with the pines, is the black-jack.

Third. Not more than one-sixth of the county is bottom land. The bottom soils are generally somewhat heavy, and are of colors and composition

varying with the uplands from which they are derived. Their thickness is often great, from one to five feet. The subsoil is commonly of heavier texture, but lighter in color than the top soil, and is underlaid at varying depths by sand, gravel, granitic, and flinty rocks, according to locality.

Tillage is easy in light sandy and difficult in heavy red lands, and is easier for all lands in wet than in dry seasons. The chief crops are cotton, corn, oats, wheat, sorghum, sweet potatoes, etc., all being equally well adapted to the soil. The cultivated land is very nearly equally divided between cotton, corn, wheat, and oats. Cotton usually attains a height of from three to three and a half feet, and is most productive when nearly or quite at its full height. One-third of the old lands are not cultivated; after several years of rest they produce nearly as well as when fresh. There is not much injury from washings except on coarse gravelly hillsides, which can be prevented by hillside ditching. Valleys are not hurt by the washings of the uplands unless clay is washed in to cover the soil. The damage from this source is usually prevented.

CLAY.

Population: 12,938.—White, 11,870; colored, 1,068.

Area: 610 square miles.—Woodland, all. All Metamorphic.

Tilled land: 57,972 acres.—Area planted in cotton, 13,921 acres; in corn, 24,503 acres; in oats, 4,834 acres; in wheat, 9,785 acres; in tobacco, 85 acres; in sugar-cane, 10 acres; in sweet potatoes, 237 acres.

Cotton production: 4,973 bales; average cotton product per acre, 0.36 bale, 513 pounds seed-cotton, or 171 pounds cotton lint.

One of the most prominent topographical features of Clay county is a high ridge (Blue Mountain) composed of siliceous rocks, which runs northeast and southwest near its western boundary. With the single exception of Talladega creek, all the streams which have their sources in the hills of Clay county, flow either southward or westward into the Coosa and Tallapoosa rivers. Talladega creek rises in the highlands east of this Blue Mountain ridge, and, flowing down the valley southwestward for 10 or 12 miles, turns northwest, and, cutting through the siliceous rocks of the mountains which form the western boundary of the county, flows out into the Coosa river across Talladega county. Approximately parallel with this ridge, and six or eight miles distant from it toward the east, there is another ridge, which is formed chiefly of mica slates, with which, however,

are associated ledges of quartz rock, which give rise to much rough and broken country. Between these two ridges there is a valley, which, with some interruptions, extends through the whole length of the county. In its upper portion, near the headwaters of Ketchapedrakee and Talladega creeks, this valley has the name of Fish-Head Valley; in the lower part of the county it is called Horn's Valley.

West of the Blue Mountain (as the western ridge is sometimes called), out to the borders of Talladega county, the rocks of clay are all aluminous slates alternating with strata of quartzite, and the resulting soils are gray, which are not very fertile. Where the siliceous rocks are most prominent, as upon the higher ridges, the soils are sandy, and support a growth of long-leaf pine; in other places the upland oaks are associated with the pines.

The soils of the valley lands, above mentioned, are of two kinds, red and gray, the former derived from the rocks which contain the mineral hornblende, and the latter from the mica and clay slates. These two varieties are in belts and patches, and it is impossible to give any detailed account of their relative distribution. The country from the eastern foot of the Blue Mountain out to the vicinity of Ashland, is in general rolling, though rising toward the east, and is made up of many alternations of mica and clay slates with the hornblendic rocks. Perhaps the most widely distributed soil is a brown loam resting on a yellow clay foundation and supporting a growth of red, black, and Spanish oaks, with a few chestnuts and hickories. A soil of this sort was collected near Mr. H. Watts', and the analysis of the same has been given on page 189. The soils of this class are good with favorable seasons, but suffer much from drouth. Going eastward, the red color and stiffness of the soils increase, and at Candutchkee they have nearly the color and texture of some of the red valley soils of the adjoining county of Talladega. This red belt is next followed by a region made up of mica slates, which, for great distances, presents almost uniform characters. These latter rocks yield a brown soil with red-clay subsoil, which usually contains fragments of the much-decayed slate. The prevailing timber is post, red, and black-jack oaks, with some

pines and hickories, the two latter, however, not very numerous. Soils of this kind may be seen from Delta to Hillabee, and probably in the continuation of the same direction to the lower limit of the county.

East of the ridge lands, between Delta and Ashland, and a few miles below the latter place, there is a belt four or five miles wide of rather low, gently undulating country called Flatwoods, covered with a mixed growth of oaks and pine, and having generally a gray and somewhat sandy soil. These flatwoods show a considerable variety as regards the fertility of the soils. Some are considered almost worthless, being too wet and too rocky for cultivation; but when good enough for cultivation the soil gives a fair yield, as all the cotton matures and there is no danger of its suffering from drouth. Beyond the flatwoods, toward the southeastern corner of the county, there is first a belt four or five miles in width of granitic rocks, yielding a gray soil, which is usually quite fertile, and this belt is succeeded in the same direction by clay slates and micaceous and siliceous rocks, which give yellowish and gray clayey and sandy soils of no great value. In wet lowlands there is much of what is called "crawfishy" land, which is worthless unless improved; but by thorough ditching, turning under of green crops, and liberal application of lime, these make very good crops, and the crawfishy character disappears. They are also often much improved by simply allowing the washings from the red lands to settle over them.

Clay county has the disadvantage of being remote from market. The northwestern border of the county, being broken and mountainous, possesses comparatively few sections whose soils are well adapted to cotton production. The bulk of this crop in Clay, is hence produced in the southern and eastern parts of the county. In the character of the soils cultivated in cotton Clay resembles Cleburne and Randolph on the one side and Tallapoosa and Coosa on the other, and the remarks there made apply also to the adjacent portions of this county.

ABSTRACT OF THE REPORT OF W. W. JENKINS, OF HILLABEE.

(The report refers to the drainage area of Enitochopka, Hillabee, and Hatchet creeks.)

The lowlands consist of first bottoms, which are generally sandy, and of gray, black, and yellowish colors; of second bottoms, which are more or less rolling, containing but little sand, and have gray, yellow, and red colors; flatwoods, a body of land twelve miles by eight in extent, mostly with gray, sandy soil, interspersed with patches of black-pine swamp land, with yellowish soil. The flatwoods have a growth chiefly of long-leaf pine, with black-jack and other oaks, some hickory, sweet gum, walnut, poplar, and patches of crab-apple, persimmon, ash, maple, dogwood, alder, etc., on the branches, and occasionally a bush of cedar. The flatwoods are of average fertility, and are not drouthy. The first bottoms are exceedingly productive; the second bottoms less productive, but surer of a crop than the first bottoms. The uplands consist of several varieties. The table-lands are very productive where hickory is found in abundance. Where the sides of the hills are heavily timbered with oaks, hickory, and poplar, with no undergrowth, there are many farms, even on steep hillsides, for the soil is always good. Many of the hills are covered with chestnut, chincapin, and sassafras, and are not much valued. A large proportion of the pine land is not considered worth cultivating; and many spots of good soil cannot be cultivated because of the great number and size of the rocks which cover the ground. In general, the summits and southern and eastern slopes of the hills are most heavily timbered and productive. The generally mountainous character of this county, with the early fall, late spring, and usually cool summers, make the cotton season very short. The caterpillar comes late, and generally does more good than harm by exposing the bolls to the sun. Guano is much used to hasten the growth and maturity of the cotton-plant. The gray lands, which predominate, are the freest and warmest, and give best returns. The first bottoms are generally too cold, and the weed grows so rank that the plant rots and molds; they are also too much shaded by the hills. The second bottoms are generally rolling, with no hills so high as to shade them too much. The flatwoods, though the soil is only of moderate fertility, yield good crops, because they are warmer, more exposed to the sun, and are visited by frosts often some weeks later than the other lands. Wet winter and spring are considered most injurious to the cotton crop, as it takes the land in the flats and bottoms a long time to dry and become warm.

The most prominent characters of the principal soil-varieties have thus been given. In the order of productiveness they would rank about as follows: the best uplands, whether red or gray, are indicated by a growth of numerous long hickory saplings; the black-pine swamp land, when properly drained, is very productive; while the yellow lands are the poorest of all. The uplands and flats are very easy of tillage, but the bottoms, being wet and rich, are likely to be overrun with grass, which is hard to manage.

The principal crop is cotton, which is cultivated on about one-half of the tilled land. The plant grows to the height of four or five feet, being most productive at four feet.

One-fourth of the land formerly under cultivation is turned out. When

again taken in, the yellow soils appear to be exhausted, but the black soils seem to be brought to life by a few years' growth of young pines, and, if they have not been burned over and the straw been allowed to rot on the ground, produce as well as ever. The uplands are all more or less easily washed, and the injury from this source is considerable. When ditching is resorted to, it is to save the uplands, since the lowlands are rather improved than injured by the washings from the uplands. Where the hillside ditches are properly cut they protect the uplands very effectually.

COOSA.

Population: 15,113.—White, 10,050; colored, 5,063.

Area: 670 square miles.—Woodland, all. All Metamorphic.

Tilled land: 80,791 acres.—Area planted in cotton, 26,468 acres; in corn, 29,990 acres; in oats, 5,325 acres; in wheat, 9,735 acres; in tobacco, 28 acres; in sweet potatoes, 412 acres.

Cotton Production: 8,411 bales; average cotton product per acre, 0.32 bale, 456 pounds seed-cotton, or 152 pounds cotton lint.

The drainage of Coosa county is westward into the Coosa river, with the exception of a small strip along the eastern edge of the county, which is within the drainage area of the Tallapoosa. The water-shed between Paint creek and Weoguffka is a prominent ridge of siliceous rocks, which runs northeast parallel with the course of Paint creek, and very near it. This ridge divides into two nearly equal parts the northwestern quarter of the county, over which prevail soils of a light or gray color and sandy texture, with a timber growth in which the long-leaf pine is always conspicuous and, at times, the principal tree. The underlying rocks, however, from which these soils are derived differ on the two sides of this ridge. Northwestward to the limits of the county these rocks are siliceous and clay slates, with sandstones and a narrow belt of limestone in the extreme northwestern corner; southeastward, over a belt six miles in width, the prevailing strata are micaceous slates, usually much disintegrated, and often filled with garnets. In the direction of the river the country is much broken, and the hills bordering the streams are in some instances 400 or 500 feet above the water level. Where the siliceous dividing

ridge above noticed is cut by the Coosa river high cliffs overlook that stream, and near the southeastern limit of this belt, and between Weoguffka and Hatchet creeks, up to the Talladega county line, steep, high ridges are numerous. Most of these hills are covered with long-leaf pine forests and are uncultivated, but hold apparently inexhaustible deposits of iron ore, which may some day be utilized.

Southeast of a line drawn from the mouth of Hatchet creek to the northeastern corner of the county alternating red and gray soils are distributed over a surface which is, in general, more undulating and less broken than that just described. The underlying rocks are also different, consisting chiefly of gneisses and granites; the presence of the mineral hornblende in many of these imparts to the soils derived from them a red or brown color. The subsoils, even of the gray varieties of soil, are mostly of reddish colors, and are usually called red clays. Between Bradford and Rockford stretches a belt of granite, which in places may be seen as huge bowlders, resulting from the disintegration of the mass. The resulting soils vary from mulatto-colored to gray, and are of varying degrees of fertility. The timber upon the red soils is chiefly oaks and hickory, and that upon the gray soils the same, with the addition of pine. The short-leaf pine is in places associated with the other trees mentioned both on red and on gray soils, but the long-leaf pine seems to grow in force only upon the lighter-colored, sandier soils.

In the vicinity of the Coosa river, and near the lower line of the county, there is a tolerably wide terrace or river plain, on an average some 150 or 200 feet above the water-level, on which the underlying rocks are mostly hidden from view by the beds of sand and pebbles of Stratified Drift. In this region the Drift alone is concerned in the formation of the soils and subsoils, since the country rocks are exposed only along the banks of the streams, and the aspect of the country is in nowise different from that which prevails over some of the southern counties of the State. In addition to the soil varieties above mentioned, there are the usual bottom soils which take their character from the uplands from which they are washed. Over all that region where the soils are closely connected with the stratified rocks angular fragments

of the quartz veins, with which these rocks are traversed, are commonly seen on the surface and in the subsoil; but as a general rule these quartz fragments are more numerous upon the gray than on the red lands.

The red and gray gneissic soils, and those of the lowlands of the various streams, especially of the Coosa river, form the best cotton lands of Coosa county. In the northwestern section the lands are much more broken and the soils less suited to cotton than is the case elsewhere. The superiority of Coosa to some of its neighboring counties in the matter of cotton production, is doubtless due to its greater proportion of good river lands.

ABSTRACT OF THE REPORTS OF J. C. M'DIARMID, OF GOOD WATER, AND JUDGE J. S. BENTLEY, OF ROCKFORD.

(*Both these reports refer to the lands drained by Hatchet creek; the former to the northeastern part of the county, the latter to the central portion.*)

The lowlands and bottoms are in some parts not planted to any great extent in cotton, but in some cases, where they are not too wet, or are properly underdrained and fertilized, they are the best cotton lands, since the plant grows to perfection and matures and opens fully before frosts. In the bottom lands there is more depth of soil and more vegetable matter, and consequently the plant never fires or sheds, even in long drouths and when heavily fertilized. The two varieties of upland soils described are the red and the gray (the latter being the gray granitic soil, and not the sandy and siliceous soil prevailing in the northwestern part of the county)

First. The gray land makes about 60 per cent. of the area described. It is timbered chiefly with oaks, hickory, and pines, the latter mostly on the uplands. The top soil is a sandy to a clayey loam of gray and other light colors from three to eight inches in thickness, with a subsoil of heavier texture and usually of a reddish or yellow color, containing angular fragments of quartz or flint. The subsoil is mostly quite pervious or leachy.

Second. The red soils make up the other 40 per cent. of the uplands, and have the usual oak and hickory growth. The top soil is a clayey loam of yellow, red, and brown colors, six or eight inches in thickness on an average, resting on a subsoil of stiff, tenacious clay, which is of a yellow or mahogany color, and rather impervious and difficult to break up at first, but which, on exposure, becomes brittle, and is then easily worked.

Tillage is easy on gray but rather difficult on red lands in dry seasons. The chief crops are cotton, corn, oats, wheat, sweet potatoes, and sorghum, the soil being best adapted to the production of the three crops first named. From one-third to two-fifths of the land is planted in cotton. Cotton is usually about three feet in height when grown, and is then most productive. Perhaps one-half of all the land at any time in cultivation now lies turned out; but the turned-out portion is being rapidly reclaimed, and when reclaimed is almost as productive as fresh land. In some cases the washings

of the slopes or hillsides is very damaging; but the injury from this source is of no great extent, and consequently no measures have been taken to prevent it.

TALLADEGA.

(See "Coosa Valley region.")

CHILTON.

(See "Gravelly Pine-Hills region.")

ELMORE.

(See "Gravelly Pine-Hills region.")

MACON.

(See "Central Prairie region.")

REGION OF COOSA VALLEY AND ITS OUTLIERS.

Comprising the whole or a part of the following counties: Cherokee, Cleburne,* Calhoun, Etowah, Saint Clair, Talladega, Shelby, Chilton,* Bibb,* Tuscaloosa,* Jefferson,* Blount,* Marshall,* Jackson,* and DeKalb.*

CHEROKEE.

Population: 19,108.—White, 16,418; colored, 2,690.

Area: 660 square miles.—Woodland, all. Coal Measures of Lookout Mountain, 150 square miles; Coosa Valley, etc., 510 square miles.

Tilled land: 88,819 acres.—Area planted in cotton, 24,388 acres; in corn, 33,373 acres; in oats, 7,477 acres; in wheat, 10,085 acres; in rye, 163 acres; in tobacco, 82 acres; in sweet potatoes, 335 acres.

Cotton production: 10,777 bales; average cotton product per acre, 0.44 bale, 627 pounds seed-cotton, or 209 pounds cotton lint.

The western boundary of Cherokee county runs along the top of Lookout Mountain, in many places near its western crest. A belt of varying width, but averaging perhaps five or six miles, along the northwestern edge of the county is

thus made of the sandstones and other strata of the Coal Measures. The soils derived from these are sandy loams of grayish to yellow colors, and the prevailing timber is a mixture of the upland oaks and short-leaf pine. For fruit cultivation these mountain summits have been found to be especially well-suited, as the crop is rarely injured by frosts.

Parallel with the southeastern edge of Lookout Mountain, and at the average distance of about a mile from it toward the southeast, runs a red-ore ridge through the whole length of the county, and between this ridge and Lookout Mountain lies a valley with a yellowish soil of very fair character (similar soil is found in Dry Valley). The red-ore ridge is of the usual character, sandy on one side and flinty on the other, and has steep slopes. Another similar ridge, called the Dirt-Seller Mountain, runs parallel with this from the Georgia line to Round Mountain, on the Coosa river, with one interruption caused by the Chattooga river. The Dirt-Seller is in reality a V-shaped mountain, with the apex of the "V" just beyond the line in Georgia, with one prong (the longer one) terminating at the Round Mountain, and the other (the shorter one) terminating at Gaylesville. The country between these two prongs is known as Dry Valley, and is a good farming area, the soil being brownish and yellowish loams. An analysis of a typical soil of this valley has been given in the general part. The country between the Dirt-Seller and the red-ore ridge at the foot of Lookout Mountain is in general ridgy land, with gray, flinty, gravelly soils. Across the Chattooga river, south from Gaylesville, and reaching into this State a few miles from the Georgia line, there is still another red-ore ridge, called Gaylor's Mountain. All this part of the county included in a triangle lying north of an east and west line through Round Mountain and Cedar Bluff is mountainous and ridgy, with the ridges and valleys running northeast and southwest; but below that line nearly to the southern boundary of the county the country is comparatively level, a large proportion of it being what is known as Flatwoods, which form a belt of four or five miles in width, occupied by the windings of the Coosa river, and is timbered generally with post oaks and short-leaf pines, with occasionally other oaks.

The flatwoods soil is a cold, yellowish-gray material, sandy in places, and in places very tough and clayey. (See analysis of soil from Saint Clair county, p. 199.) Probably on account of the level character of the land and its bad drainage the flatwoods are not, as a rule, much in cultivation, though the analysis shows that they are by no means sterile soils.

Southeast of the flatwoods belt, to the mountainous region in the lower part of the county, the land is gently undulating, and the surface soil is sandy and mixed with rounded pebbles of quartz, precisely similar to the pebbles of the Drift further south. This sandy land has a characteristic growth of long-leaf pine with black-jack oaks, the genuine piny-woods timber, and the pine belt extends through the county into Etowah without material change. Both the piny-woods and the flatwoods belts are based upon siliceous and calcareous shales, and where the soil is not too sandy on the one hand (from the overlying Drift sands) or too clayey on the other (from the shaly portions of the country rock) it is sometimes very good cotton land. The cutting of pine timber gives occupation to a large number of the inhabitants of this belt, and "log-yards" are established at every convenient bluff along the river. Toward the southeastern edge of the piny woods, where the surface Drift has not so completely covered the country rocks, there are many strips of long-leaf pine land, with soil derived from a siliceous sandstone, alternating with strips of loamy land derived from calcareous shales, having a growth of post oaks and short-leaf pines. This whole area—flatwoods, piny woods, and the mixed land just mentioned—is less generally under cultivation than the other parts of the county.

As we approach the southern and southeastern limits of the county the topography becomes much varied, and mountainous elevations, composed of sandstone and chert, rise up abruptly from the general level, making short ridges of five to ten miles in length, and often over 1,000 feet in height above the surrounding country. These mountains are of two kinds, sandstone and flint or chert, those formed of the sandstone being the higher and the more important. They

inclose coves of red fertile valley land, such as is described under Calhoun and Talladega counties, and they alternate in the most irregular way with the flint ridges. The sandstone mountains are timbered usually with oaks and short-leaf pines, while the characteristic growth of the flint ridges is the long-leaf pine. Upon these flint ridges lie strewn immense masses of light-gray or whitish chert, and if the soils were much more fertile than they are in reality these flint fragments would offer serious obstacles to cultivation. In a similar way the sides of the sandstone mountains are covered with huge fragments of that rock. In the coves, and often upon the sides of these mountains and hills, lie the most valuable deposits of brown iron ore, which is worked up at numerous furnaces along the Selma, Rome and Dalton railroad. This railroad in Cherokee county runs chiefly in coves between the sandstone mountains which occupy the southeast corner of the county.

Between this group of mountains and the Coosa valley proper, before described, there is a region of ridgy and valley lands, with good red and brown loam soils, based on limestones; and beyond these rises the Wisenar Mountain, a ridge of sandstone flanked on the eastern side with lower ridges of chert. The Wisenar is about six miles long, and its lower or southern end is nearly in the southwestern corner of the county.

The cultivated soils of Cherokee are in general terms to be classed as red and brown loams derived from limestones—gray, flinty gravel soils, which as a rule cover the ridges which traverse the valleys, and sandy soils near the river, based upon the drift. To these might be added the sandy and flinty soils of the mountains, which are, however, not much in cultivation.

The relations of Cherokee county agriculturally are very well shown in the following abstract. The high product per acre shows that the better lands are selected for cotton.

ABSTRACT OF THE REPORT OF DR. JOHN LAWRENCE, OF CEDAR BLUFF.

The lowlands of the Coosa, Chattooga and Little rivers, and Terrapin and other creeks, embrace a small proportion of black alluvial soil and close mulatto and coarse white sand in some localities. The uplands comprise the mountainous, hilly, rolling valley and table lands near these rivers, with

post-oak flats and pine woods, the soils being quite varied, and embracing many qualities, and the flatwoods and long-leaf pine sections are almost valueless for cultivation. The river and creek bottom lands, together with the valley and table-lands, are the most productive.

Cotton culture in the region described has greatly improved within the last few years. Wet weather in the spring frequently retards planting, and drouth in July and August causes shedding. We also have cut-worms and lice in the early stages of the plant, and caterpillars and rust later. The most important soils in the cultivation of cotton are:

First. The light mulatto-colored and gravelly lands of the valleys, and of the table-lands near the river. These are sandy loams, timbered with oak, hickory, chestnut, short and long-leaf pine. The lands near the river are rather lighter and more sandy, but more even and of smoother texture than the long-leaf pine soils. These are usually lightly timbered, and are easily cleared and cultivated, but very quickly exhausted; yet the subsoil in most cases is heavier, and when mixed with the surface soil, is greatly improved, especially for cotton production. In both soil and subsoil, the brighter the color the better the quality.

Second. The ridge lands have usually gray or light-colored soils, with yellowish subsoils, containing angular flinty gravel, and supporting the usual upland growth of oaks and hickories.

Third. The light-colored and mulatto sandy soils of Lookout Mountain, with yellowish subsoil, and an upland growth of oaks, hickory and short-leaf pine.

All the soils that are profitably cultivated have subsoils of dull yellow and red colors, usually of finer texture than the surface. In addition to the above, there are some valley soils that are considered scarcely worth cultivation. These are (1) the long-leaf pine lands, which have a thin sandy soil and yellowish to nearly white clayey subsoil in the low grounds, but of darker colors on the elevated lands, frequently covered with rounded pebbles; (2) the flatwoods, which have a very thin soil, and a subsoil of white or light-gray crawfishy clay, containing in many places flat fragments of the shale from which it is derived. The soil and subsoil are often much alike, containing always more or less lime, and rotten lime-rocks may be found underneath in most localities. Both the pine lands and flatwoods are burned over every year, and hence there is no accumulation of vegetable matter.

All the cultivated lands are of easy tillage, if properly prepared and with favorable seasons. They are rather cold, and imperfectly drained as a class, and are well adapted to cotton, corn, wheat and oats. From one-third to two-fifths of the cultivated lands are in cotton, which attains a height of from two and one-half to six feet, being most productive at three and one-half feet.

On fresh soils, the seed-cotton product per acre, with proper cultivation, varies from 500 to 1,200 pounds, of which 1,425 pounds are required to make a 475-pound bale, the staple rating as low middling to middling when properly handled. After twenty years' cultivation, without manure and without rest or rotation, the yield would be light, say from 100 to 1,000 pounds, according to the original strength of the land. In these cases, the proportion of lint would probably be less and the staple shorter. The most troublesome weed is crab-grass, but briers and other weeds are often bad.

Not more than ten to fifteen per cent. of the originally cultivated land is turned out, and when this is again taken into cultivation, it produces very well, especially if fertilizers are judiciously applied. The rolling lands are quite easily injured by washings, and the damage from this cause is often serious. But little if any injury is done to the valley lands from such washings. The only remedy as yet applied has been horizontalizing, and in the few instances where this has been properly done, the results have been satisfactory.

CLEBURNE.

(See "Metamorphic region.")

CALHOUN.

Population: 19,591.—White, 14,134; colored, 5,457.

Area: 640 square miles.—Woodland, all. Coosa Valley, 610 square miles; Coosa Coal-fields, 30 square miles.

Tilled land: 93,857 acres.—Area planted in cotton, 26,435 acres; in corn, 33,714 acres; in oats, 8,852 acres; in wheat, 10,745 acres; in rye, 287 acres; in tobacco, 29 acres; in sweet potatoes, 283 acres.

Cotton production: 10,848 bales; average cotton product per acre, 0.41 bale, 585 pounds of seed cotton, or 195 pounds cotton lint.

The western boundary of Calhoun county below Greensport is formed by the Coosa river; above that town by a red-ore ridge, which enters this county from Saint Clair. The eastern boundary is formed by a continuation of the same mountains which form the eastern limit of Talladega county. These mountains are the highest within the county limits, and the next most important heights are found in the sandstone mountains which traverse the county northeast and southwest, in general east of the Selma, Rome and Dalton Railroad, and at no greater distance (six to eight miles) from the eastern boundary. One range of these mountains extends, without serious break, from near Cross Plains down to the vicinity of Oxford. At this place there is a gap, and the continuation of the range, under the name of Coldwater Mountain, is found on the western side of the railroad. Besides this principal range, there are several smaller peaks or spurs on each side of the main body of the mountain. The long range may be called the Jacksonville or Ladiga Mountain, and plays an important part in de-

termining the direction of some of the water-courses of the county, the tributaries of Terrapin and Choccolocco creeks having their sources east of this range, in the valley between it and the mountain which forms the eastern boundary of the county. The latter stream flows southward down this valley to near the southern line of the county, and then turns westward through a gap and falls into the Coosa; the former, on the contrary, flows northward around the end of the mountain through a similar gap, and thence northwestward through Cherokee county into the river. The other streams of the county rise on the western side of the sandstone range. The valley drained by Choccolocco and Nance's creeks is based on the flinty magnesian limestone, and presents the usual fluted structure—flint ridges, alternating with fine valley lands with red soil. The red soils prevail in the lower levels, while gray gravelly soils characterize the uneven ridgy lands. West of the mountain range spoken of, the country presents the same alternation of flint ridges and red valley lands out to a series of hills of sandstones and other rocks of the Coosa Coal-field, which occupies a narrow belt of four or five miles' width near the northwestern boundary of the county. In this intermediate region, between the two mountainous and hilly tracts just specified, there is a large area of fine valley land, with the usual red and brown soil, resting on red clay loam. The region about Alexandria is of this character, and some of the most desirable farms in the county are in this belt, which extends through its whole length.

The red level lands are, as usual, separated by flint ridges, and all the varieties between the deep-red and the light-gray gravelly soils are to be found. An analysis has been made of a red valley soil from near Jacksonville (see page 204). In the upper portion of the county, the flint ridges often broaden out, embracing large areas, which have the usual gray sandy, gravelly soil, changing to yellowish at two or three inches, and resting on a yellow clay at three feet depth. This soil supports a growth of long-leaf pine, with post and Spanish oaks and small hickories. In general, the flint ridges of this kind nearly always have a growth of long-leaf pine, and in the northeastern part of the county,

where the sandstone mountains and the flint ridges are in close proximity to each other, the former have mostly oak timber, while the latter have the pine. In some instances, however, pine grows also upon the sandstone soils. At the northwestern border of the county, the flint ridge which forms a part of the red-ore range is of different quality, being clothed with oak growth without pine.

The low hills of the Coosa Coal-field, while crossing the northwestern corner of the county, have little influence on the topography, as they have been much worn down, and the soils derived from them are, as usual, sandy and rather poor, in striking contrast to the rich red soils of the adjacent valley.

The valley lands of Calhoun are usually selected for cotton planting, as is the case in this section generally, and the high product per acre may be taken as indicating the superiority of the soil. The soils of the other counties included in the Coosa Valley region, viz: Etowah, Saint Clair and Talladega, are of the same nature as those of Calhoun and Cherokee, and the relations of all these counties to the production of cotton are practically the same.

ABSTRACT OF THE REPORTS OF DR S. C. WILLIAMS, OF OXFORD, AND T. W. FRANCIS, OF CANE CREEK.

(The first of these reports refers to the region about the Choccolocco (eastern valley), the second to that about Crane creek (western valley), and both relate to uplands as well as lowlands.)

In the lowlands the cotton is liable to rust, especially on old land, say from five to thirty years in cultivation. The lowlands are, therefore, better suited to wheat and oats, but good crops of cotton are made on them when fresh. For many reasons the uplands are preferred for cotton, especially if the soil is of fair quality, which is generally the case for 10 or 12 years, after which time it usually requires fertilizers. Late springs and early frosts tend to reduce the crop. The most important soil is a reddish or mulatto soil, which makes about two-thirds of the cultivated land in the valley. The natural timber on such land is red, black, white, post, turkey and Spanish oaks, hickory, walnut, etc. The top soil is a gravelly, clayey loam of gray to brown and black colors, about 12 inches thick, and with a yellow or red clay subsoil, which becomes like the soil after cultivation. This mulatto soil grades into a gray soil in the hilly slopes, and the subsoil of both is a yellow clay, redder in the case of the mulatto soils. This subsoil always contains flinty or cherty gravel, and, in the red varieties, also pebbles of iron ore. The underlying rock is a limestone, which is reached at from 10 to 50, feet depth. From one-third to one-fifth of the land, according to locality

is bottom or made land, with a growth of beech, poplar, sweet gum, walnut, hickory, elm, ash, etc. The soil is a sandy or clayey loam from one to five feet in thickness, with a yellowish or bluish-white clayey subsoil, containing flinty pebbles, and resting on the limestone at varying depths. In the vicinity of Cane creek there is a soil-variety known as slate or post-oak land, which is timbered with post oak and black-jack, the top soil of which is a gravelly, in some cases putty-like, material, from two to six inches in thickness, and of a whitish color; and the subsoil a soft, black slate, which becomes hard on exposure to the air, and is then somewhat impervious. This land is not of much value, being almost worthless after a few years' cultivation. Upon the mountains there is a coarse, sandy soil of a whitish to gray color, four to six inches in thickness, with a subsoil which is like the surface soil, but with more flint intermixed with white, sandy clay. All rest upon a flinty substratum. This soil supports a growth of long-leaf pine, mixed with black-jack and small trees, is the extreme of the flinty soils, and is found only on the ridges and mountain slopes. On account of its uneven and knobby character, it is liable to wash, and, being rather barren, is not much under cultivation.

Land is generally easily tilled in both wet and dry seasons. The chief productions are cotton, corn, wheat, oats, and rye, and the soil is well adapted to cotton and grain. At least one-half of the land is planted in cotton, which usually grows to a height of three feet. The soil does not wash much on slopes or hillsides, but the valleys are rather benefitted than injured by the washings from the uplands. Whatever damage may result from rain on the slopes can be readily prevented by hillside ditching.

ETOWAH.

Population: 15,398.—White, 12,896; colored, 2,502.

Area: 520 square miles.—Woodland, all. In Coosa Valley, 250 square miles; in Wills' Valley, 90 square miles; in Murphree's Valley, 40 square miles; Coal Measures, 140 square miles (40 on Lookout Mountain and 100 on Sand Mountain).

Tilled land: 60,780 acres.—Area planted in cotton, 15,187 acres; in corn, 24,891 acres; in oats, 5,025 acres; in wheat, 7,063 acres; in tobacco, 47 acres; in sugar cane, 9 acres; in sweet potatoes, 230 acres.

Cotton production: 6,571 bales; average cotton product per acre, 0.43 bale, 612 pounds seed-cotton, or 204 pounds cotton lint.

Etowah county includes parts of two mountain plateaus and three valleys. All these natural divisions have a northeastern and southwestern direction through the county. The valley of the Coosa forms the eastern and southeastern parts of the county, and, like most of the valleys of the

State which depend upon the geological structure for their existence, is a complex trough made up of several smaller valleys divided by ridges. The river, with its windings, occupies the central part of this valley, which is a gently undulating plain of five or six miles in width. This plain is based upon a shaly limestone which yields a clayey soil, usually badly drained, and not generally under cultivation where the limestone is near the surface. In the vicinity of the river, however, these limestones, together with their resulting soils, have been pretty generally covered with a deposit of loam, sand, and rounded pebbles, and these materials are more concerned in the formation of the soils than the underlying country rocks. Upon such soils the prevailing timber is long-leaf pine, which follows the river plain throughout the county and into Cherokee. The marginal belts on each side of the main valley are fluted with smaller valleys separated by flint ridges, and present the usual variety of yellowish clayey and gray gravelly soils, the latter predominating upon the hillier portions and the former upon the more level areas.

Another belt of valley land stretches southwest below Gadsden to the county-line and beyond. In this area the sand and pebbles are mostly wanting, and the soils are dependent altogether upon the shaly rock. This whole region is quite level, and has a cold, yellowish, clayey, badly-drained soil, covered as a rule with its original timber growth, chiefly of post oaks and short-leaf pines, with red, Spanish, and black-jack oaks, and occasionally sweet and sour gums. This belt has the name of "the flatwoods", and it is comparatively little cultivated, although the natural growth and the chemical analysis, as given on page 208, would indicate a soil of very fair quality. The trouble seems to be more due to defective drainage and other physical causes. On each side of this flatwoods belt are found the cultivated lands of the valley, which, are, as usual, disposed in belts of mahogany land alternating with the gray gravelly land of the ridges.

From the northeastern corner of the county to Gadsden stretches the lower extremity of the Lookout Mountain plateau, which is capped with the rocks of the Coal Meas-

ures, yielding sandy or slightly loamy soils and supporting a growth of upland oaks and short-leaf pine. From this plateau flows Black creek, making, where it leaves the mountain, near Gadsden, a fine waterfall, which is one of the attractions of that vicinity. Parallel with Lookout Mountain, toward the northwest, and separated from it by Wills' Valley, is the entirely similar plateau of Sand Mountain. Beyond Sand Mountain a part of the northwestern boundary of Etowah county is formed by Murphree's Valley. These two valleys are in all essential respects similar to each other, and their structure is already described at length in the general part.

The valley soils are principally of two varieties, the red or yellowish and the gray soils, and as a rule the former occupy the subordinated valleys between the chert ridges upon which the latter are most commonly found. Several analyses of each of these soil-varieties have been given in the general description. The sandy soils are chiefly confined to the plateaus of Lookout and Sand Mountains. The extreme southeastern boundary of the county is formed by a high cherty ridge, and a similar ridge runs nearly parallel with this and five or six miles west on the opposite side of the river, terminating at a bend in the river a few miles below Gadsden. Between these is the wide valley of the Coosa.

In its relations to cotton culture Etowah corresponds closely to Calhoun, which it adjoins, and the remarks there made will apply here also.

ABSTRACT OF THE REPORT OF W. B. BEESON, OF GREENWOOD.

(*This report refers to the drainage area of Little Wills' creek.*)

All classes of uplands produce reasonably well when properly cultivated. As this is near the northern limit of the cotton belt, it is best, in order to escape damage from frosts, to stimulate the plant to early maturity by the use of fertilizers. On bottom lands liable to overflow there is no cotton planted because of overflow and of early frosts. The soil-varieties described are:

First. The dark mulatto or mahogany, which makes about one-half of the cultivated lands of the two Wills' valleys, and supports a growth of oaks, hickory, chestnut, and walnut. The top soil is a sandy loam of a brown to mahogany color, six to twelve inches in thickness, with a subsoil of heavier clayey texture, resting upon the limestone rocks at varying depths.

Second. The gray and dark gravelly lands, which divide the areas of the two valleys about equally with the preceding, and which support nearly the same natural growth. The top soil is lighter both in color and in texture than the preceding, and the same is true of the subsoil; but the subsoil is heavier and contains more clay, and also, as a rule, contains angular pebbles of flint.

Third. The sandy soils upon Sand and Lookout Mountains, having the usual characters of the mountain soils. These sandy lands are easily cultivated. Clay is more crusty after rains, and waxy when not so wet. The uplands are rolling, and hence naturally well drained. The chief products are cotton, corn, wheat, oats, millet, sorghum, sweet potatoes, and clover. All kinds of land are fitted for corn and sorghum, and all kinds of uplands are suited to cotton. About one-third of the cultivated lands is in cotton, which grows generally to a height of from three to four and a half feet, the highest being most productive unless the rains have been excessive. Land does not seem to be injured by the first four or five years of cotton culture; indeed, cotton does not exhaust the soil as rapidly as many other crops. Very little land that was ever in cultivation is turned out. The soil washes on sandy or gravelly slopes, and on some hilly farms the damage is very considerable, but the valleys are improved by the washings from the uplands. There is some hillside ditching to protect the slopes, which is beneficial when well done.

SAINT CLAIR.

Population: 14,462.—White, 11,621; colored, 2,841.

Area: 630 square miles.—Woodland, all. Coosa and Cahaba valley lands, 430 square miles; Coal Measures, 200 square miles (Coosa field, 150; Cahaba field, 50).

Tilled land: 65,105 acres.—Area planted in cotton, 14,735 acres; in corn, 25,465 acres; in oats, 4,603 acres; in wheat, 9,841 acres; in tobacco, 53 acres; in sweet potatoes, 226 acres.

Cotton production: 6,028 bales; average cotton product per acre, 0.41 bale, 585 pounds seed-cotton, or 195 pounds cotton lint.

The northwestern boundary of Saint Clair county is formed by Blount Mountain, which is the southern end of one of the prongs of Sand Mountain, already known as a part of the coal-fields of the State. In the northwestern corner of the county Chandler's Mountain, about six miles long and two miles wide, is of the same formation. The Coosa Coal-field, occupying a belt some five or six miles in width, runs nearly parallel with the Coosa river, which forms the southeastern boundary of the county, and at an

average distance from it of three or four miles. In addition to these the northeastern extremity of the Cahaba Coal-field runs up into Saint Clair county as far as the latitude of Springville. Between these mountainous or hilly lands, which the Coal Measures always form, lie the main valleys—Coosa valley between the river and the Coosa coal-field, and Cahaba valley between the Coosa and Cahaba coal-fields. These valleys are themselves complicated by ridges running their whole length, dividing them up into narrow ribbons or subordinated valleys differing widely from each other.

It will thus be seen that Saint Clair county presents a great variety in its topographical and other natural features. The topography, soils, timber, and other characters of the Coal Measures are about the same everywhere, the lands upon the smaller ridges being of two distinct sorts. The red-ore ridges run always parallel to the edge of the Coal Measures, usually less than a mile distant, and are formed of sandstones and cherty limestones, the sandstones being commonly found on one side of the ridge and the chert on the other. These ridges are often high and steep, and form a prominent feature of the landscape. Their characteristic soil is a red calcareous loam, which is specially suited to the production of small grain, but not of cotton, the slopes being usually too steep to permit cultivation to any great extent. Where the red-ore feature is not prominent the chert or flint, which also enters into the composition of the ridges, becomes the characteristic, and the slopes are covered with its sharp angular fragments, the soil thus formed, while very rocky, being quite fertile, as is shown by the luxuriant growth which covers it. In this respect the Red Mountain chert ridges are, as a rule, to be distinguished from the chert ridges which are based upon a lower formation, the former being often called oak ridges, while pine is a characteristic growth of the latter.

Between the red-ore ridges and the Coal Measures there is always a small valley of yellowish or mahogany-colored soil of more than average fertility. This soil is similar to that of the red lands of the valley of the Tennessee, and its

composition is shown in the analysis of Dry Valley soil from Cherokee county (see page 210).

Next to the red-ore ridges (toward the center of the valley) the land is at first rather level and of good quality; then succeeds the cherty, gravelly lands, interspersed with flint ridges of lower Silurian origin. These have a gray gravelly soil of medium fertility (see analysis of the soil collected near Ashville, page 204). The red or yellowish valley soil from the same locality is the type of the other class of valley soils. These yellowish soils, like the gray, are more or less mixed with angular flinty pebbles, but occasionally a cove of fertile red land may be found inclosed by ridges of the white angular cherty gravel, Clayton's cove, just over the line in Jefferson county, below Springville, being an instance.

From Springville northeastward along the line of the Alabama Great Southern railroad there is a level country called the "flatwoods," with cold, yellowish soil, very little cultivated, and mostly covered with its original growth of post oak and pine, and in places with other oaks and gums. This soil is derived from a shaly limestone.

Saint Clair closely resembles the other counties of this section, and, as regards cotton culture here, the remarks under Calhoun county will apply equally well.

ABSTRACT OF THE REPORT OF JUDGE JOHN W. INZER, OF ASHVILLE.

(This report refers to the region of Big Canoe creek, a tributary of the Coosa river.)

Wet, cold springs and summer drouths, more than anything else, injure the cotton in this region. The soils described are three, viz:

First. Gray upland soil, often full of cherty gravel. This makes about three-fourths of the cotton land of the region, but not quite one-half of the whole valley lands. The usual timber consists of oaks, poplar, and short-leaf pine. Along the Coosa river the soil is sandier, and long-leaf pine prevails. These are the best cotton lands. The top soil is a fine sandy loam in the bottoms, and gravelly loam on the uplands; color, gray; thickness, about three inches. The subsoil is a reddish or buff clay, except in the bottoms, where it is sandy. It contains angular pebbles of chert or flint, and is underlaid at 20 to 25 feet by a siliceous magnesian limestone.

Second. Red or mulatto upland soil. This makes a little over a half of the valley lands of the county, but not more than a fourth of it is planted in cotton, since it suits the grain crops much better. The timber is oak, hickory, poplar, etc. The top soil is a clayey loam of the colors above

given, and has an average thickness of four inches; the subsoil is also a clayey loam, heavier than the top soil, containing angular cherty pebbles, and frequently, also, concretions of brown iron ore. This is underlaid with the same magnesian limestone that forms the basis of the preceding.

Third. The sandy bottom lands. These make only one-tenth of the cultivated area, and are found along the Coosa river and Canoe creek. In the former locality there is much long-leaf pine associated with the other growth. The chief growth of the bottom land is white and red oaks, poplar, and hickory. The top soil is a fine sandy loam of dark-gray color and five inches in thickness; subsoil heavier, being mixed with some clay. It contains, also, angular cherty pebbles like the others, and rests on the magnesian limestone, at from six to eight feet.

Land is easily tilled in both wet and dry seasons, as it is early, warm, and well drained. The crops are corn, cotton, oats, and some wheat, but corn and cotton are best suited to the soil. One-half of the cultivated land is planted in cotton, which, unfertilized, grows three and three and a-half feet high, and is generally most productive just before attaining full height. Not much land is turned out; and when such land is taken into cultivation again it produces for two or three years very nearly or quite as much as when fresh. The slopes or hillsides are often much injured by rains. Valleys are also injured by the washings of the uplands, which injury is checked on some farms by hillside ditching.

TALLADEGA.

Population: 23,360.—White, 10,856; colored, 12,504.

Area: 700 square miles.—Woodland, all. All Coosa Valley and ridge land.

Tilled land: 113,389 acres.—Area planted in cotton, 32,841 acres; in corn, 40,376 acres; in oats, 9,278 acres; in wheat, 13,235 acres; in rye, 143 acres; in tobacco, 30 acres; in sweet potatoes, 335 acres.

Cotton production: 11,832 bales; average cotton product per acre, 0.36 bale, 513 pounds seed-cotton, or 171 pounds cotton lint.

Talladega county lies between a range of high hills on the east and the Coosa river on the west. The water-courses, with the exception of Talladega creek, have their sources on the western side of this range, which in part of its course is called Blue Mountain, and flows westward into the Coosa. Talladega creek has its headwaters in the mountains beyond the borders of the county, cuts its way through the highest of these, and flows thence southwestward into the river. The three principal streams of the county are, beginning at the north, Choccolocco, Talladega, and Tallasseehatchee

creeks, which, with the smaller streams, (Blue Eye, Clear, and Cedar creeks) receive all the drainage of the county.

The highest elevations in the county are found in the range which makes the eastern boundary—Blue and Rebecca Mountains. Next in point of height are the mountains of sandstone of the Lower Silurian age, which occupy the central parts of the county. These mountains, like all made by this formation, consist of detached ranges, which, rising up abruptly from the plains, extend 15 or 20 miles, and then sink down quite as abruptly at the other end, beyond which, after an interval of five or ten miles, another similar range makes its appearance. West of the Selma, Rome, and Dalton railroad, from Choccolocco creek to Alpine station, a distance of 15 miles or more, one of the most prominent of these ranges may be seen. At Alpine the height of one of the peaks is 2,000 feet above the railroad, or 2,495 feet above the sea level. Northeast of the city of Talladega the peak called Mount Parnassus is a prominent landmark in that vicinity. Below Alpine, the continuation of this range is found on the other side of the railroad, and its direction is changed to the south and east, and near its eastern extremity it is known under the name of Pope Mountain.

The lower part of the county is mostly occupied by a number of short ranges and peaks which have the collective name of the Kahatchee Hills. Near Childersburg and Coosa bridge these mountains approach quite near to the river. A prominent peak in this vicinity is 800 feet in elevation above the river. All the mountains of this character are formed chiefly of sandstone, with some calcareous shales, which, however, never become prominent. The resulting soils are necessarily sandy and of no practical value. An oak growth covers the sides and summits of all these ranges, but on account of the huge masses of rock which form the surface, cultivation is out of the question, even if the soils were fertile. Upon the summits there is a scanty growth of gnarled and stunted trees, chiefly oaks.

Between these mountains and the eastern border of the county, and also between them and the river, are the valley lands, which are far, however, from being uniformly level.

Based as they are chiefly upon flinty and magnesian limestones, these valley lands are traversed by flint ridges, which have a direction from northeast to southwest, and which, in the eastern part of the county, lie between narrow belts of valley land with fertile red and brown soils. These soils and their subsoils are usually filled with angular fragments of flint, and where this becomes a prominent ingredient the red color disappears and the soil, as well as subsoil, becomes gray. The gray lands are commonly rather more broken than the others, lying frequently upon the sides of the flint ridges above spoken of. The valley lands east of the mountain ranges before described constitute the most attractive part of Talladega county, and it would be difficult to find anywhere a section which has greater natural advantages than the belt of country lying east of the railroad as far south as the Kahatchee Hills. The timber of this region consists of red, black, white, Spanish, and post oaks, hickory, and gums.

Where the soils are of a deep-red color, the subsoil is mostly full of pebbles of brown iron ore, which are sometimes present in quantity sufficient to constitute true ore banks. Where these masses of iron ore cover the surface (even sometimes to the extent of seriously interfering with cultivation) the soil is, nevertheless, highly fertile. The gray or ridgy lands have a characteristic growth of long-leaf-pine, but other trees, especially oaks, are associated with it.

West of the sandstone mountains spoken of, and especially in the vicinity of the river, the chert or flint very much predominates. In this region, which embraces a belt four or five miles in width along the river from Choccolocco to Talladega creeks, is a succession of chert ridges, with gray flinty, siliceous soil, timbered almost exclusively with long-leaf pine, interspersed with lime-sinks. The chert is sometimes accumulated in hills of considerable size, as in Calhoun Mountain, near the mouth of Talladega creek, which is at least 350 feet above the river level. In some localities, as northwest of Plantersville, these pine woods are gently undulating, and the cherty fragments only occasionally show above the surface. This whole region, because of the ster-

ility of the soils, is comparatively uninhabited except along the banks of the very few creeks which traverse it, but it has its value as a range for cattle. Inclosed by these barren flinty hills are occasional coves of excellent land with red calcareous soils. Howell's cove, west of Talladega, may be cited as an example. In the region of the Kahatchee Hills there are many fine coves of red, fertile soil, hemmed in on three sides by the mountains.

Near the eastern border of the county, below the Kahatchee Hills, the beautiful Talladega Valley extends quite to the southern limit of the county. In this section is situated the well-known Sulphur Spring. Of all the watering places in the State this has the most attractive surroundings.

The valley lands of Talladega are well suited to the culture of cotton, as is shown by the comparatively high product per acre. The low percentage of tilled land in cotton gives evidence that other crops are more profitable.

ABSTRACT OF THE REPORTS OF H. M. BURT, S. M. JEMISON, AND A. W. DUNCAN, ALL OF TALLADEGA.

(These reports are descriptive of the soil-varieties occurring throughout the valley east of the railroad.)

The principal soil is the red valley soil, which makes nearly three-fourths of the cultivated land of the area described. This is timbered with red, post, and black-jack oaks, hickory, persimmon, and sassafras. The top soil varies from a light, fine sandy to a rather heavy clay loam of mahogany to brown and nearly black colors, and is from one to twelve inches thick. The subsoil is usually heavier, being mostly a tough red clay, containing angular fragments of flint and rounded pebbles of iron ore. It rests upon lime-rock, which is found at the average depth of 20 feet.

A gray gravelly soil makes about one-eighth of the area embraced by the reports, which is timbered with pine, mixed with other trees, such as oaks and hickory. The top soil is a sandy, gravelly loam, occasionally a clay loam, of a whitish to gray color, with an average thickness of two inches. The subsoil is usually heavier and yellowish in color, containing flinty gravel in quantity, and is underlaid first with sand, and below that with the lime-rock.

Still another eighth of the region is made up of the first and second-bottom lands, which have a growth of beech, poplar, sycamore, iron-wood, sweet gum, etc. The soil is a sandy loam of gray to blackish colors, and some 12 inches in thickness; the subsoil a tough clay, hard at first, but becoming soft by cultivation. It also contains flinty, angular pebbles, and is underlaid with sand and the lime-rock at varying depths.

Land is usually easily tilled both in wet and dry seasons. The principal crops are cotton, corn, wheat, and oats, but the soil is best suited to corn and cotton. From one-third to one-half of the land is planted with the latter, which is generally from two to four feet high when grown, and yields best at or about the full height. About one-fifth of the land is turned out, but such land brought into cultivation again will, with suitable fertilizers, produce good crops. In some places there is serious damage done to the hillsides by heavy rains, but the valleys are rather improved by the washings of the uplands. This damage has been checked to some extent by horizontalizing.

SHELBY.

Population: 17,236.—White, 12,253; colored, 4,983.

Area: 780 square miles.—Woodland, all. Valley lands, 385 square miles (Coosa and Cahaba); Coal Measures, 395 square miles (Coosa field, 235 square miles; Cahaba field, 160 square miles).

Tilled land: 58,550 acres.—Area planted in cotton, 17,919 acres; in corn, 26,159 acres; in oats, 4,764 acres; in wheat, 6,294 acres; in tobacco, 10 acres; in sweet potatoes, 346 acres.

Cotton production: 6,643 bales; average cotton product per acre, 0.37 bale, 528 pounds seed-cotton, or 176 pounds cotton lint.

The northwestern part of Shelby county is formed by the Coal Measures of the Cahaba field; the central belt by those of the Coosa field. Between the two is the Cahaba Valley, and east of the Coosa field the valley of the Coosa. The eastern edge of the Cahaba field as far south as Helena has a northeastern and southwestern direction, but below that it turns southward to Montevallo, and thence westward to the line of Bibb county. These Coal Measures have the usual rugged surface, and sandy and not very fertile soils which are always found in such regions. The whole area is drained by the Cahaba river, which flows southwest the entire length of the county. Tributaries of the Little Cahaba drain the southern edge of this field in the vicinity of Montevallo. The direction of the main streams in this region has determined the topography. The principal ridges, with their dividing valleys, have a general northeastern and southwestern trend. The Cahaba Valley, which is on an

average four or five miles wide, has the usual features of the narrow valleys of central Alabama. It is fluted by a number of ridges with intervening depressions running parallel with its length. A flint ridge, with gray, gravelly soil, and with oak and pine timber, commonly occupies the central portion of the valley, and red-ore ridges, with oak timber and red sandy loam and gravelly soils, lie near the two margins. On the eastern side the red-ore ridge is more or less prominent throughout the length of the county, but on the west it is often wanting altogether, in which respect this valley differs from those lying to the north and west. The subordinated valleys lying between these ridges are based on limestones, which are of varying degrees of purity, and hence the great variety in their soils as to composition and fertility. The two principal varieties are the yellowish loamy soil, with red clayey subsoil, and the gray soil with subsoil filled with angular fragments of lint. The analyses given on page 204 of soils from the valley near Ashville, in Saint Clair county, show the character of similar soils in this county. In the lower part of the valley, near Montevallo, there is a great development of deep-red soils, derived from the lower limestones of the valley formation. These are in composition and derivation similar to the red valley soils, of which an analysis has been given under Calhoun county (page 204). The flinty or cherty portions of the limestone near Montevallo lie often upon the surface in huge masses of most irregular shape, and where this chert prevails the soil is poor and long-leaf pine abundant. In the same region is another class of soils derived from gray, greenish, and chocolate-colored shales, of which, however, no chemical examination has yet been made.

The soils and other characters of the Coosa Coal-field are, in the main, similar to those of the Cahaba field, but the center of the former field is occupied by a narrow belt of limestone, yielding very good yellowish or mahogony soils, like those of Dry Valley, in Cherokee county. This limestone belt is a feature peculiar to the Coosa field. The lands of the Coosa Valley are, in general terms, like those above named. There is, however, a prevalence of gray cherty or flinty soils near the river, which support a mag-

nificent growth of long-leaf pine. South and southwest of Columbiana this pine growth reaches great proportions, and has furnished for many years the fuel of the Shelby furnaces.

In the southern part of the county, below the latitude of Helena, the underlying formations are in many places more or less hidden by the beds of sand, loam and pebbles of a later period, and the surface soils are in such cases derived from these overlying beds. The best of these soils is a brown loam, which characterizes the Oak Upland region of all the lower part of the State, and has been mentioned in some detail in many places. About Columbiana, the prevailing soil is a yellowish or buff-colored loam, which lies in good position, and is generally under cultivation. Northeast of that town is a small mountain, which incloses some coves of good farming land. The mountain itself is high, steep and rocky.

While Shelby belongs to the agricultural division of the Coosa Valley, it partakes also of the character of the Gravelly Hills; hence, while we find a larger per centage of the tilled lands in cotton, the product per acre is less. The soils of the latter division, though probably intrinsically poorer as a rule than those of the valley region, are yet perhaps better suited to cotton than to other crops; hence, a larger proportion of the former.

ABSTRACT OF THE REPORT OF T. A. HUSTON, OF WILSONVILLE.

(This report refers to the drainage area of Yellow Leaf creek and the immediate valley of the Coosa river.)

The best cotton land is found on the easy rolling slopes, in patches varying in size from one to five acres. In the flats, the plant does not mature its entire crop in time to escape killing frosts, unless highly stimulated with fertilizers; otherwise, the heavy gray lands with a yellow clay subsoil would be our best cotton lands. (This kind of subsoil does not retain manures well.) The most important cotton soil is a sandy loam resting on a red-clay subsoil, which makes perhaps one tillable acre in every six. Its timber consists of oaks, hickory, pine, chestnut and mulberry. The top soil is a coarse, sandy, and gravelly loam of a light color, about four inches in thickness, with a subsoil of red compact clay, stoutly resisting the plow, hardening when exposed to the sun, and an excellent retainer of all manures. It contains angular fragments of flint, and this material often lies at the surface as large rocks. At eight to forty feet depth is found the flinty limestone of the country. The other principal soil variety has been men-

tioned above. It is a heavy gray soil with yellowish-clay subsoil, but for reasons given it is not cultivated in cotton.

Lands are difficult to till in wet seasons. The chief crops are cotton, corn, wheat, oats, sorghum, and potatoes, but the soil is best adapted to corn and oats. About one-third of the land is planted in cotton, which usually grows to a height of three feet. Perhaps one-third of the land originally cultivated is now turned out; but such lands taken again into cultivation generally surpass the fresh lands. The soil on the hillsides is washed to a serious extent, and the valleys are sometimes rendered worthless by the washings of the uplands. The damage is checked to some extent by hillside ditching.

CHILTON.

(See "Gravelly Pine-Hills region.")

BIBB.

(See "Gravelly Pine-Hills region.")

TUSCALOOSA.

(See "Gravelly Pine-Hills region.")

JEFFERSON.

(See "Coal-Measures region.")

BLOUNT.

(See "Coal-Measures region.")

MARSHALL.

(See "Coal-Measures region.")

JACKSON.

(See "Tennessee Valley region.")

DEKALB.

(See "Coal-Measures region."

COAL-MEASURES REGION.

Comprising the whole or part of Jackson,* DeKalb, Cherokee,* Calhoun,* Etowah,* Marshall, Madison,* Morgan,* Cullman, Blount, Saint Clair,* Shelby,* Jefferson,

Walker, Winston, Lawrence,* Franklin,* Marion,* Lamar,* Fayette,* Tuscaloosa,* and Bibb* counties.

JACKSON.

(See "Tennessee Valley region.")

DE KALB.

Population: 12,675.—White, 11,993; colored, 682.

Area: 740 square miles.—Woodland, all. Wills' Valley, 250 square miles; Coal Measures, 490 square miles (on Lookout Mountain, 100 square miles; on Sand Mountain, 390 square miles).

Tilled land: 52,096 acres.—Area planted in cotton, 7,469 acres; in corn, 23,929 acres; in oats, 5,115 acres; in wheat, 6,846 acres; in rye, 383 acres; in tobacco, 19 acres; in sweet potatoes, 218 acres.

Cotton Production: 2,859 bales; average cotton product per acre, 0.38 bale, 543 pounds seed-cotton, or 181 pounds cotton lint.

The greater part of DeKalb county is occupied by the plateau of Sand Mountain, a high plain, whose surface rocks are the sandstones and conglomerates of the Coal Measures. The eastern boundary of the county runs northeast and southwest near the crest of the plateau of Lookout Mountain, which is in all respects the counterpart of Sand Mountain. The two are separated by Wills' Valley, which extends through the county from northeast to southwest near its southeastern border. The highest points of the two mountains are along the edges of the valley which they inclose, and the slopes overlooking the valley are usually very steep, sometimes high cliffs, continuous for many miles, and almost insurmountable. Upon the mountain tops the land slopes gently away from the rims next the valley. Little river and its tributaries drain the Lookout Mountain plateau and Town creek that of Sand Mountain. Upon the former, near Valley Head, are the beautiful falls of Little river, over ninety feet in height, with a deep rocky gorge below the falls.

The mountain soils are somewhat sandy, of a gray to yellowish color, and the timber consists of the usual upland

oaks, with hickory, and, in places, short-leaf pine. Their cultivation is of comparatively recent date, the first settlers preferring the valley lands, which were originally more fertile. As the valley lands have become worn the mountains have been brought under cultivation, and there are now many considerable farms both upon Sand and Lookout Mountains. Upon these plateaus fruit trees seem to thrive, and the crop is rarely killed or injured by frosts. Cotton also is here successfully cultivated with the aid of moderate quantities of fertilizers. The analysis of a soil collected on Sand Mountain near Valley Head will show the chemical constitution of the average soil of these plateaus (see page 217).

The valley above spoken of is about six miles in width, and is in reality a complex trough, made up of four more or less well-defined smaller valleys, separated by three flinty or cherty ridges. At the foot of the mountains on both sides of the valley are narrow valleys, whose soils are yellowish loams of very good quality, resembling in character the soils of Dry Valley, in Cherokee county, of which an analysis is presented on page 211. The other sides of these narrow valleys are bounded by red-ore chert ridges, in which have been found in several places beds of fire-clay of exceptionally good quality, and the working of these deposits gives employment to many. The center of the great valley is occupied by a more or less continuous ridge of chert, on each side of which are small valleys based upon the magnesian limestones.

Taken as a whole, the valley soils may be classed under three heads: the yellowish or mulatto loams of the valleys proper and sandy and cherty soils of the ridges. The character of the first has already been indicated.

The cherty soils vary considerably. The colors are gray to yellow, and the average composition would be near that of the *barrens* soils of northern Alabama. Where the slopes are not too steep and the surface not too much broken these soils are successfully cultivated. The small chert ridges which lie nearest to the foot of the mountains have, as a rule, on one side sandy and on the other flinty or cherty soils. These ridges are, however, usually so steep that they

are seldom much in cultivation, except near the foot. An analysis of soil from Red Mountain, in Saint Clair county, has been given on page 208, which will show the general character of these soils. They are nowhere considered good cotton soils, being mostly devoted to wheat and other grain.

At Valley Head is the water-parting between the Tennessee and the Coosa drainages, the former by Lookout creek and its tributaries, the latter by Big and Little Wills' creeks. The latter flows near the foot of Lookout Mountain, the former near the center of the main valley.

DeKalb county is occupied in great part by the two plateaus of Sand and Lookout Mountains, upon neither of which is cotton cultivated to any great extent. Cotton culture is mostly confined to Wills' Valley; hence the comparatively small percentage of tilled land in cotton, though the high product per acre attests the superiority of the soils selected for this crop. Cullman and Blount counties present similar conditions.

CHEROKEE.

(See "Coosa Valley region.")

CALHOUN.

(See "Coosa Valley region.")

ETOWAH.

(See "Coosa Valley region.")

MARSHALL.

Population: 14,585.—White, 13,084; colored, 1,501.

Area: 560 square miles.—Woodland, all. Coal Measures, 375 square miles (253 square miles on Sand Mountain; 140 square miles on the mountain spurs northwest of the valleys); valley of Tennessee, 185 square miles (140 square miles in Brown's and Gunter's Valleys, south of the river; 50 square miles in Tennessee Valley north of Guntersville; 95 square miles coves and slopes of the mountain spurs).

Tilled land: 68,175 acres.—Area planted in cotton, 16,412 acres; in corn, 27,113 acres; in oats, 3,471 acres; in wheat,

5,797 acres; in rye, 150 acres; in tobacco, 48 acres; in sugar-cane, 51 acres; in sweet potatoes, 243 acres.

Cotton production: 5,358 bales; average cotton product per acre, 0.33 bale, 471 pounds seed-cotton, or 157 pounds cotton lint.

Marshall county is divided about equally by a valley which traverses it from northeast to southwest. This valley is a trough cut down through the Coal Measures into the limestones and other rocks of underlying formations. The Tennessee river flows down it as far as Guntersville, at which point it turns northwest, cutting through the rim of the Coal Measures which bounds the valley on that side. Below Guntersville the valley extends through Marshall and Blount counties, under the name of Brown's Valley. The valley is a complex one, being made up of at least three smaller valleys, separated by ridges of flint or chert, which are parallel to each other. These subordinated valleys have red or brown-loam soils based upon limestone, and are in general characters similar to the red soils of the great valley of the Tennessee.

The valley lands are level or slightly rolling, and have been generally cultivated. Big springs and lime-sinks are numerous and characteristic throughout the whole region. The dividing ridges above mentioned have mostly light-gray soils with reddish or yellowish subsoils, containing angular fragments of chert. The ridge lands are of varying degrees of fertility, supporting a timber growth which often indicates no mean soil, but the steepness of the slopes generally prevents their being brought into cultivation.

The valley rim on the eastern side is nearly continuous, but is indented here and there with gaps cut by the creeks which flow down from the elevated land on that side. This table-land or plateau of Raccoon Mountain is an elevated, shallow trough, highest at its edges adjacent to this valley on the one side, and to Wills' Valley, in De Kalb county, on the other side. The rim on the other side of the valley, below Guntersville, is similarly high and abrupt, but in the northwestern quarter of the county the rim has lost by erosion much of its original height, and its table-land character has in great measure disappeared. Upon all these

highlands there is a capping of sandstones and conglomerates of the Coal Measures, and the resulting soils are of the kind described under DeKalb and Jackson counties, where the same formations are found.

Marshall county has a comparatively large proportion of valley lands suited to cotton culture. The sandy lands of the Coal Measures have not yet been extensively planted in this crop, although with fertilizers they yield well.

MADISON.

(See "Tennessee Valley region.")

MORGAN.

(See "Tennessee Valley region.")

CULLMAN.

Population: 6,355.—White, 6,312; colored, 43.

Area: 590 square miles.—Woodland, all. All Coal Measures.

Tilled lands: 20,527 acres.—Area planted in cotton, 1,469 acres; in corn, 10,343 acres; in oats, 1,179 acres; in wheat, 2,569 acres; in rye, 480 acres; in sugar-cane, 66 acres; in tobacco, 41 acres; in sweet potatoes, 215 acres.

Cotton production: 378 bales; average cotton product per acre, 0.26 bale, 372 pounds seed cotton, or 124 pounds cotton lint.

Cullman county is situated upon what has been termed the plateau, which is the southern prolongation of the Cumberland table-land. The southeastern boundary of the county is partly formed by Brown's Valley, or rather by the high rim of the valley. This high level land extends thence north and northwest to the southern limit of the great Valley of the Tennessee, in Morgan county. The table-land is drained partly into the Tennessee and partly into the Warrior river, the line separating the two systems of drainage being near the northern boundary of this county. The South and North Alabama railroad traverses the county, and the following altitudes will show the average elevation: Phelan, 692 feet; Cullman, 802; Milner, 840; Willhite's, 608 feet above tide. Blount Springs, which is in the valley

on the one side, and Decatur on the other side of the county, have the altitudes of 434 and 577 feet, respectively. Geologically, this county is formed of the Coal Measures, and mostly of the lower strata of the same, for the limestones of the Sub-Carboniferous formation are exposed above the drainage level in the valleys on each side of the table-land on which Cullman county is situated. The Stratified Drift, which plays so important a part both in the geological structure and in the soil formation of the counties west of Cullman, is here almost wanting. The soils of Cullman are derived almost exclusively from the disintegration of the strata of the Coal Measures, and vary according as these are sandstones and conglomerates or shales.

Cotton is a subordinate crop in all this region, yet experience has recently shown that these light sandy soils with good stiff subsoils respond well to fertilizers, and yield very fair crops with a moderate outlay for manures. It is probable that a larger proportion of these lands is now planted in cotton than ever before.

ABSTRACT OF THE REPORT OF WILLIAM J. DUNN, OF CULLMAN.

(This report refers to the hilly, rolling, and table-lands lying along the headwaters of the Warrior river.)

This whole region is interspersed with many small streams, all tributary to the Warrior. These streams have very little first-bottom lands, and the whole area is much varied with spots of good and poor land. Warm weather, with occasional moderate rains, is much the best for growing crops, and fair uplands are preferred to the low or wet lands for cotton culture. The most important soil is a light sandy loam, which makes about 90 per cent. of the county. Of much less importance are the dark sandy loams and the sandy bottoms. The growth upon the uplands consists of post and red oaks, short-leaf pine, chestnut oak, hickory, maple, dogwood, etc. The soil is usually a sandy or gravelly loam, sometimes a heavier clayey loam, of gray to brown colors, and averaging four inches in thickness; the subsoil is rather heavier, being a reddish clay mixed with gravel, hard when dry, and underlaid with slate in some places and sandstone in others. Land is easily cultivated in wet and dry seasons alike, and rarely needs draining. The crops produced are cotton, corn, wheat, oats, rye, tobacco, sorghum, and millet. The soil is very well adapted to all these crops, and is specially good for growing grapes, peaches, and apples. Only about one-fifth of the land is planted in cotton, which usually grows not more than three feet high. A rest of two years to "turned out" lands is beneficial, but longer rests permits the land to grow up in bushes and sedge-grass.

BLOUNT.

Population: 15,369.—White, 14,210; colored, 1,159.

Area: 700 square miles—Woodland, all. Coal Measures, 460 square miles; valley lands, 240 square miles (Brown's Valley, 170 square miles; Murphree's Valley, 70 square miles).

Tilled land: 68,860 acres.—Area planted in cotton, 12,502 acres; in corn, 29.161 acres; in oats, 4,551 acres; in wheat, 10,087 acres; in tobacco, 48 acres; in sweet potatoes, 371 acres.

Cotton production: 4,442 bales; average cotton product per acre, 0.36 bale, 513 pounds seed-cotton, or 171 pounds cotton lint.

The central part of Blount county is formed by the high plateau of Raccoon Mountain, which occupies a belt from eight to ten miles in width running from northeast to southwest through the county. On the northwestern side of this plateau is Brown's Valley; on the southeast, Murphree's Valley. Raccoon Mountain faces these valleys with a more or less continuous line of cliffs elevated several hundred feet above the general level, the height, as a rule, diminishing coming southward. The highest parts of the mountain lie along the edges of these valleys, the central part of its plateau being a pretty well defined basin, down which flows one of the main branches of Black Warrior river. Near this stream the level is somewhat lower than that of the two valleys. The whole of this mountain basin has the sandstones and other beds of the Coal Measures for surface rocks, and the soils derived from them are the usual light-yellowish sandy loams, whose average composition is fairly shown by the analysis of a soil from DeKalb county (see page 217). The timber is composed of the species of upland oaks, with hickory and some short-leaf pine. These lands have lately been much esteemed as cotton lands, the use of moderate quantities of fertilizers insuring a good return, and in many places better and more profitable crops have been raised upon this land than upon the intrinsically more fertile valley lands. As pastures, and for the cultivation of fruit, particularly of peaches and apples, this region is

equal to any in the State. The fruit crop is rarely, if ever, cut off by frosts.

The valleys above mentioned are two deep troughs cut down by denudation into the lower rocks of the geological series. From the circumstance that these valleys have been worn down from the crest of a fold in the strata, the central parts of the same, while much lower than the mountain rims, are often higher than the country a short distance back from the rim. It thus often happens that the water rising in the valleys makes its way through these rims into the basin of Coal-Measures, of which they are a part.

Brown's Valley, on the northwest, is in reality, for most of its length, a double valley, Brown's being the western and Gunter's, or Big Spring Creek valley, the eastern. The two are separated by a flint or chert ridge, made up in great part by the siliceous fragments of the Sub-Carboniferous limestones. The eastern, or Gunter's Valley, has for its basis the limestones of this age, and the soils are the red and brown loams so prevalent in the great Valley of the Tennessee. In the upper part of this valley, near the water-parting between the Tennessee and the Warrior rivers, there is a great development of the sandy strata of the same formation (the rock which caps the Little Mountain in Franklin and Lawrence counties), and the soils are gray or light-yellow sandy loams, timbered with oak, hickory, and short-leaf pine. In Brown's Valley, the calcareous rocks of a much lower geological formation, appear at the surface, but the derived soils are yellowish clayey loam, not materially different from those of the other valley.

Between this valley and the rim of Coal Measures which forms a part of Sand Mountain, intervenes a ridge of the sandstone just spoken of, and at the western slope of this ridge, and at the foot of Sand Mountain, there is a narrow valley of the same limestone, which underlies the Eastern or Gunter's Valley. The soil varieties, therefore, occurring in this complex valley are numerous, but are essentially of three kinds, viz: the red or brown calcareous loams of the valleys proper, resting on limestones; the flinty or cherty soils of the flint ridges before named, which are closely related to the soils of the *barrens* of the region north of the

Tennessee river; and, lastly, the sandy soils prevailing on the water-parting previously mentioned. These do not differ materially from the soils of Sand and Raccoon Mountains. In the lower part of the valley the flint ridges above mentioned reach a great height, as may be seen from the following list of elevations above tide: Blountsville, 807 feet; Wooten's peak, 1,200 feet; another peak (not named), 1,400 feet. Near the lower end of the valley are situated the well known Blount Springs, and to the northwest there is a narrow strip of Sand Mountain belonging to this county, as the line follows the Warrior river.

Murphree's Valley, on the eastern border of the county, is in many respects similar to that just described. In both, the rocks of a geological formation, much older than that of the Coal Measures, appear at the surface and form the soils. Both are higher than the basins on each side, though the rims of these basins which form the borders of the valleys are several hundred feet higher than the valley lands. Murphree's is also a complex valley, being divided by ridges running parallel with its longest dimensions. These dividing ridges are mostly cherty or flinty, and the little valleys between have the reddish calcareous loamy soils which characterize the other valleys. Much of the gray flinty-ridge soils, especially where the lands lie well and are not too hilly, produce very fair crops, though they are not generally so much esteemed as the so-called red-clay soils.

The southeastern corner of Blount is occupied by a mountain plateau, similar to that making up the central belt of the county, and upon the eastern edge of this mountain runs the boundary line toward Saint Clair county.

Cotton culture in Blount county is chiefly confined to the valley lands; hence the small per centage of the tilled lands in this crop, and the comparatively high product per acre.

ABSTRACT OF THE REPORT OF GEORGE D. SHELTON, OF BROOKSVILLE.

(This report refers to the lands drained by Big Springs creek, in the eastern or Gunter's Valley.)

The soils described are, first, the loamy valley soil, which extends up and down the valley its whole length. Its timber is beech, walnut, poplar, sycamore, etc. The top soil is a sandy, gravelly, or clayey loam of gray, yellow, brown and red colors, according to locality, thickness from six to

twelve inches, and subsoil a thick loam, becoming under cultivation like the top soil. The subsoil usually contains angular flinty pebbles, and is underlaid at from three to eight feet by limestone. This is the most important soil of this region. Subordinated to it are, second, the dark gray or mulatto lands, and third, the gravelly, sandy and crawfishy lands, both based on sandstone rock. The dark-gray lands have a timber of post and Spanish oaks, hickory, pine and black gum. Its subsoil is much of the same description. The gravelly sandy lands are timbered with short-leaf pine, maple, chestnut and sweet gum. The color is whitish to gray; the thickness, one or two inches only; the subsoil is also light colored. This soil is better adapted to oats and rye, and is very little used in cotton planting.

Tillage is a little difficult in wet weather. The crops are cotton, corn, wheat, etc., but the soil is best adapted to corn and wheat. Only about one-fourth of the land is planted in cotton, which grows from two to three feet high. No land is turned out. The soil does not generally wash or gully on the slopes or hillsides.

SAINT CLAIR.

(See "Coosa Valley region.")

SHELBY.

(See "Coosa Valley region.")

JEFFERSON.

Population: 23,272.—White, 18,219; colored, 5,053.

Area: 960 square miles.—Woodland, all. Coal Measures, 760 square miles (Warrior field, 630 square miles; Cahaba field, 130 square miles); valley lands (Roup's and Jones' Valleys), 200 square miles.

Tilled land: 71,959 acres.—Area planted in cotton, 14,220 acres; in corn, 30,928 acres; in oats, 4,708 acres; in wheat, 10,589 acres; in rye, 83 acres; in tobacco, 55 acres; in sweet potatoes, 504 acres.

Cotton production: 5,333 bales; average cotton product per acre, 0.38 bale, 543 pounds seed-cotton, or 181 pounds cotton lint.

Jefferson county is divided into two unequal parts by a long narrow valley which traverses it from northeast to southwest. Northwest of this valley, and forming nearly two-thirds of the area of the county, are the Coal Measures of the great Warrior field, and southeast the Coal Measures of the Cahaba field. In their natural features, the Coal

Measures are everywhere more or less alike, usually hilly and broken, and with soils, in the main, sandy and of medium fertility, varying in quality with the underlying rock from which they are derived, which may be shale, sandstone, or conglomerate. The timber varies from that of fair oak uplands to piny woods. The scenery is usually much more varied than either the soils or the natural growth.

In striking contrast to these rugged hills is the valley, which is a deep trough, not a simple depression, but fluted with ridges and hollows which run parallel with its length. The lower part of this trough goes by the name of Roup's, and the upper part is called Jones' valley. It varies in width from four to ten or twelve miles, but where widest, in the northern part of the county, it is in reality doubled by the confluence of two valleys. The floor of this valley is higher than the general level of the country on each side, and all the creeks rising in it sooner or later break through its mountain rims and flow off into the rugged region beyond. Close to the rim of Coal Measures, on each side of the valley, there is a ridge containing red iron ore, which rises to the proportions almost of a mountain, first on one side and then on the other of the valley, being rarely of equal height on opposite sides. Between these ridges and the rim intervenes a narrow valley with very fair soils.

Between the two red-ore ridges lies the main body of the valley, which is, in its entire length, divided by one (sometimes two) flint ridges, as they are called, made up mostly of angular fragments of chert, the remnants of the impure siliceous limestone which forms the basis of the valley. In places the flint ridge attains very considerable height, and it is usually covered with a growth of post, black-jack, and other upland oaks. The hollows between the ridges are of various qualities—sometimes flat and glady, overgrown with cedars, and not in cultivation because of the proximity of the limestone to the surface; sometimes gently undulating and covered with a yellow or mulatto soil, which produces well all the common crops. These latter are the typical valley lands. Along the slopes of the ridges, and occasionally making up nearly the entire valley, are somewhat broken lands with gray soil and buff subsoil, filled with an-

gular fragments of flint or chert. These varieties all depend upon the varying quality of the siliceous magnesian limestone which usually underlies the central parts of the valley.

In addition to the above, there is in places a cold yellowish flatwoods soil, which, because of defective drainage and other physical properties, is seldom in cultivation. Between old Jonesboro' and the railroad station and southward the flint ridge becomes a very prominent feature, as it passes into a sandstone or conglomerate and widens out into a series of rugged hills several miles in width, timbered with long-leaf pine, and wholly uninhabited. These Salem Hills extend from the Jonesboro' station southward about six miles. The two valleys separated by the flint ridge have often distinct names. 'Possum valley lies west of the ridge and Jones' Valley east of the same. In several places the red-ore ridge is duplicated on one side of the valley, thus producing additional complications and a greater variety in the valley lands. McAshan Mountain is the name given to one of these duplicated red ridges, which is ten or fifteen miles long on the western side of the valley between Jonesboro' and Tannehill. Northeast of Birmingham the valley widens out and eventually divides, one fork taking the name of Murphree's Valley, the other continuing as Jones' Valley, the former mostly in Blount county. The two are separated by a point of the Coal Measures called Blount Mountain.

The red-ore ridge which follows the edge of Blount Mountain southwest of the point of that mountain breaks up in a series of high knobs, which have the general name of Cedar mountains, from the circumstances that the limestones forming the great mass of the hills makes the surface and are covered with a dense growth of cedars. Occasionally, where the red ore and its accompanying sandstones form the summit of the hills, they have received the name of Button mountains, from the great abundance of the "buttons" or segments of the stems of crinoids with which they are filled. At this point of bifurcation of the valley the distance between the Cahaba Coal-field on the east and the edge of Sand Mountain on the west is some ten or fifteen

miles. On the east, near the Cahaba field, is Jones' Valley, and on the west, next to Sand Mountain, the Back Valley, as it is called. Between the two is the broken country before spoken of, formed by the Cedar and Button mountains, and also by the ridges of chert which are invariably found in all these valleys. The rugged character of this part of the county is still further increased by the fact that the red-ore ridge itself is duplicated from Red Gap to the county line, just below Springville. Between this duplicated red mountain and the similar ridges on the west, near the foot of Blount Mountain, is Clayton's Cove, embracing about three or four square miles, and hemmed in on all sides by red ore and flint ridges. The soil in this cove is the mulatto or red valley soil, with its accompanying gray flinty gravelly soil. It is all cleared and in cultivation, and quite thickly settled.

Between the base of Blount Mountain and its red-ore ridge there is always a valley of greater or less width, according to locality, with yellowish or buff soil based on the Sub-Carboniferous limestone. Its character is well shown in the analysis of the soil from Dry Valley, in Cherokee county (see page 204). The slopes of the red ridges and the Cedar mountains, where not too steep and where the rocks are not too near the surface, are generally in cultivation. They are well suited to corn and wheat, but not to cotton. A soil of this kind from near Springville, in Saint Clair county, has been analyzed (see page 210).

Jefferson county has a large proportion of valley lands giving high product per acre, upon which alone in this section cotton is usually planted in any large quantity.

WALKER.

Population: 9,479.—White, 8,978; colored, 501.

Area: 880 square miles.—Woodland, all. All Coal Measures but small areas, especially in the western part of the county, are covered with Drift.

Tilled land: 46,725 acres.—Area planted in cotton, 8,743 acres; in corn, 21,838 acres; in oats, 2,579 acres; in wheat, 5,420 acres; in rye, 81 acres; in tobacco, 69 acres; in sugar-cane, 11 acres; in sweet potatoes, 325 acres.

Cotton production: 2,754 bales; average cotton product per acre, 0.31 bale, 441 pounds seed-cotton, or 147 pounds cotton lint.

In the northwestern corner of Walker county there is a high ridge capped with pebbles and sand. This ridge is a water-shed in its entire length in Winston, Walker, Fayette, and Tuscaloosa counties. From its position in Walker county, and from its general direction in other counties, it will be seen that the drainage of Walker county is toward the southeast. Near the dividing ridge spoken of the land is high and gently undulating, with a soil and subsoil derived from the materials of the Stratified Drift formation, which forms the surface in that part of the county. Near the mouths of the streams which flow into the Warrior river, however, denudation has produced an extremely rugged country, with high, steep hills, and deep ravines between.

Near the southern extremity of the county the two forks of the Warrior river, known as the Locust and the Mulberry forks, come together, forming the main river. A part of Walker county lies between these two branches, as the line between Walker and Jefferson counties follows the water-parting. The elevation of this ridge above the river is not far from 275 feet. Close to the river in several places there are high ridges, capped with pebbles, with an elevation of 400 feet above the river level. This is, however, rather an exceptional height, as the general elevation of the country between the streams is not much over 200 or 250 feet.

In the northeastern part of the county, adjoining Blount and Winston counties, the scenery is rugged, on account of the proximity to the surface of thick beds of hard sandstone and conglomerate, into which the streams have cut their channels. The soils vary with the formations from which they are derived, those in the western corner being mainly derived from the Drift and Loam, presenting the usual characters. Over the greater part of the county, however, they are derived directly from the sandstones and other rocks of the Coal Measures, and vary with the locality. As a rule, the soils of the Coal Measures are rather sandy and not very fertile; yet there are many areas of very good

farming land, especially in the bottoms and lowlands of the various streams. In the vicinity of South Lowell, six miles north of Jasper, there is an isolated patch of long-leaf pine forest occupying perhaps a township.

The abstracts of the reports under Winston and Cullman counties describe soils which are similar to those of Walker.

No railroad traverses Walker county, and the long distances to which it is generally necessary to haul the cotton crop in wagons is a bar to its successful production.* The yield per acre is very fair, but cotton is planted only on about 20 per cent. of the land.

WINSTON.

Population: 4,253.—White, 4,236; colored, 17.

Area: 540 square miles.—All woodland. All Coal Measures, but in the western part of the county these rocks are covered with Drift.

Tilled land: 17,767 acres.—Area planted in cotton, 2,048 acres; in corn, 8,098 acres; in oats, 579 acres; in wheat, 1,967 acres; in sweet potatoes, 172 acres.

Cotton production: 568 bales; average cotton product per acre, 0.28 bale, 399 pounds seed-cotton, or 133 pounds cotton lint.

The main dividing ridge between the waters of the Warrior and Tombigbee rivers runs almost north and south through the entire length of Winston county, near its western line. This (the Byler) ridge, in the northwestern part of the county, also divides the waters of the Warrior from those of the Tennessee river, flowing through Big Bear creek. The greater part of the drainage of the county, therefore, is southeast into the Warrior river, the principal streams being Blackwater creek and the Sipsey fork of the Warrior river, with its tributaries, Clear creek, Brushy fork, and Rock creek. On the western side of the Byler ridge are the sources of the Buttahatchie and New rivers, which flow into the Tombigbee, and of Big Bear creek, a tributary of the Tennessee.

Although there are in this county no ridges except those

*The Georgia Pacific Road, recently constructed, changes all this, and puts Walker county in communication with all the markets.

formed by denudation, there is a gradual increase in the height of the land going northward from the Warrior river, through Walker and Winston, into the southern part of Lawrence county, where the southern boundary of the Tennessee Valley and the northern boundary of the Warrior Coal-field is formed by Sand Mountain. The summit of this mountain, where it overlooks the Valley of the Tennessee, has an average elevation above the general level of the latter of 475 or 500 feet.

The face of the country throughout Winston county is generally much broken. The map will show a great number of small streams which rise in the northern and western part of the county, and which, by their confluence, form the three or four principal streams mentioned above. The sandstones and conglomerates of the Coal Measures underlie, usually at no great depth below the surface, the whole county. These harder rocks are often underlaid with softer strata of shales, and the action of running water during the rainy seasons is to wear away the softer slates, thus undermining the sandstones, which break off in large masses, forming perpendicular cliffs. The undermining, thus described, causes the formation of overhanging ledges or "rock houses", which are to be found at the head and frequently along the sides of nearly all the ravines leading down toward the water-courses. These rock houses are the localities where the rarest and most beautiful ferns flourish. The creeks and other streams of Winston county have cut their channels down through these sandstones, and often flow through deep gorges with nearly perpendicular sides. In some instances rapids and waterfalls are produced, the Clear creek falls being the best known of these. The waters of the creek here pour over two bluffs of conglomerate, each about 30 feet in height, the two being about 300 yards apart. Below the falls the creek flows down a deep, narrow gorge. These falls rival in beauty many which, in other parts of the world, are annually visited by thousands of tourists.

Over the Coal Measures, in the western part of the county, are tolerably thick beds of sand, pebbles, and loam of Stratified Drift age, which form the soils and subsoils. In the eastern parts, however, these beds decrease in thickness,

and are almost entirely wanting east of the center, where the soils are, in great degree, derived from the disintegration of the rocks of the Coal Measures. The soils so derived are seldom very fertile, being usually rather sandy; the shales, however, yield loamy soils, which form, sometimes, very fair farming lands. The ridges between the water-courses in this region are not much in cultivation, both on account of the distance to springs of water and on account of the commonly rather thin soils, and the usual growth consists of post, red, and Spanish oaks, chestnut, sour gum, and, in some places, short-leaf pine.

The farming lands are mostly in the lowlands and in the creek bottoms, where the soil is of greater depth and more fertile. Where the Stratified Drift forms the surface, there is the usual variety of soils, frequently described in other parts of this report.

ABSTRACT OF THE REPORT OF F. C. BURDICK, OF HOUSTON.

(This report refers to the region drained by Yellow creek, a tributary of Sipsey fork.)

The uplands are preferred for cotton, as it is liable to be late in the lowlands. The three principal soils described are the brown-loam upland soil, the Yellow creek second-bottom loam soil, and the light, sandy bottom soils of Brush and Clear creeks. The first makes about seven-eighths of the land of the region described, and has a natural growth of red, white, and black oaks, hickory, short-leaf pine, chestnut, and poplar. It is a fine, sandy loam of a brown color of an average thickness of 20 inches, with a subsoil of yellowish clay, hard when first exposed, but mixing readily with the surface soil. In cultivation it is almost impervious when undisturbed. This subsoil rests upon hard sand-rock at depths varying from three to seven feet. The brown-loam lands of Yellow creek bottom make a tenth of the region reported upon. The natural timber growth is composed of oaks, poplar, beech, holly, and occasionally spruce pine. The soil is a fine, sandy loam of mixed brownish to black colors, with a thickness of two feet; the subsoil is heavier, a reddish clay, hard, not mixing readily with the surface soil, and is usually free from pebbles. It is also underlaid at eight to twelve feet depth by hard sandstone. The light, sandy loams of Brush and Clear creeks have usually a brown color and a thickness of 15 inches. The subsoil is lighter, being usually a coarse sand, containing very few white pebbles.

The chief crops are corn and cotton, the latter being best adapted to the soil. About one-fourth of the land is planted in cotton, which usually reaches the height of three or four feet. Land is generally benefited by being turned out.

LAWRENCE.

(See "Tennessee Valley region.")

FRANKLIN.

(See "Tennesse Valley region.")

MARION.

(See "Oak and Hickory Uplands, with Short-leaf Pine.")

LAMAR.

(See "Oak and Hickory Uplands, with Short-leaf Pine.")

FAYETTE.

(See "Oak and Hickory Uplands, with Short-leaf Pine.")

TUSCALOOSA.

(See "Gravelly Hills, with Long-leaf Pine.")

BIBB.

(See "Gravelly Hills, with Long-Leaf Pine.")

TENNESSEE VALLEY REGION.

Comprising the whole or a part of the following counties: Jackson, Marshall,* Morgan, Madison, Limestone, Lauderdale, Lawrence, Colbert, and Franklin.

JACKSON.

Population: 25,114.—White, 21,074; colored, 4,040.

Area: 990 square miles.—Woodland, all. Valley lands, 500 square miles (190 square miles in immediate Valley of the Tennessee; 310 square miles, coves and slopes of the mountain spurs north of the river, half of which may be red valley lands); Coal Measures table-lands, 490 square miles (200 on Raccoon Mountain, south of the river, and 290 square miles on the mountain spurs north of the river).

Tilled land: 123,924 acres.—Area planted in cotton, 19,685 acres; in corn, 60,285 acres; in oats, 8,241 acres; in wheat,

10,051 acres; in rye, 347 acres; in tobacco, 99 acres; in sweet potatoes, 592 acres.

Cotton production: 6,235 bales; average cotton product per acre, 0.32 bale, 456 pounds seed-cotton, or 152 pounds cotton lint.

The surface of Jackson county is probably more broken than that of any other county in the Tennessee Valley in northern Alabama. The valley down which the Tennessee river flows divides the county into two parts: Raccoon Mountain on the southeast, and the spurs of the Cumberland mountains on the northwest. It has an average width of about four miles, the greater part of this area being north of the river, leaving only a narrow strip on the other side. This valley is based on the racks of the Lower Silurian formation, which consists of limestones, shaly, aluminous and flinty, or siliceous. The narrow bottom of the river is usually underlaid with the Trenton limestones, which also sometimes make low bluffs along the banks. The soils derived from these beds are calcareous loams of considerable fertility. Northwest of these lowlands a series of low ridges, one or two miles in width, run parallel with the course of the river through the whole county. These ridges are made by the flinty or siliceous limestones of the Lower Silurian formation, and are covered with a light-gray soil, usually filled with angular fragments of chert, and support a growth of short-leaf pines and occasional hickories. These soils resemble very much the soils of the *barrens*, though derived from entirely different rocks.

South of the Tennessee, Raccoon Mountain faces the river with a line of cliffs almost continuous throughout the entire length of the valley, the narrow space between the river bottom and the foot of the mountain being occupied by a ridge of the cherty fragments of the lower Sub-Carboniferous formation. Between this flint ridge and the foot of the mountain there is a narrow valley of very good reddish and yellowish soils, and where this valley is wide enough and the lands somewhat level these make excellent farming lands, as might be expected from the fact that they are derived from rocks the same as those which form the basis of the red lands of the great Valley of the Tennessee.

Along this line of cliffs the points are few at which the mountain can be ascended, and the roads lead up by gradual slopes or tortuous zigzags cut along the mountain side. When the top is reached there is the usual plateau, very broad in this case, extending beyond the limits of the county. The monotony of this table-land is relieved by shallow ravines and depressions, along which run the creeks and spring branches. All the streams of this plateau are shed from the higher eastern edge, in De Kalb county, and flow diagonally across the plateau, and off from the mountain on the Jackson county side. Where they leave the mountain they have usually cut deep, narrow gorges, which present, especially near their heads, wild and picturesque scenes. The height of the table-land is from 1,800 to 2,000 feet above the sea, and from 800 to 1,000 feet above the adjacent valleys, and the timber consists principally of the various species of upland oaks, hickories, and short-leaf pines. The soils are light-gray and yellowish sandy loams, the general composition of which may be seen from the analysis of the Sand Mountain soil from near Valley Head, in De Kalb county (see page 217). While intrinsically less fertile than many of the valley soils, these are far from sterile, and are now being very generally taken into cultivation by a class of small farmers. The table-lands have long been noted for the excellent pasturage which they afford.

The edge of the Tennessee Valley on the north side is very irregular, and is deeply indented by coves of nearly level fertile land, which are underlaid by the rocks which form the basis of both the red and the barren lands (the latter, however, to a very limited extent) of the counties westward. Some parts of them is usually also indebted to the Mountain Limestone formation for its soils, and in this way there are many grades of fertility in lands of these coves. The ridges separating these coves, while decreasing in height toward the river, nevertheless terminate against the river valley in a series of heights with rather abrupt slopes, called the river hills, which are intermediate in level between the valley plain and the main body of the ridges. Near the river, where denudation has produced its greatest effects, those parts of the ridges which separate the coves

have in many places been cut across by side ravines, and are thus more or less completely separated from the main body of the Cumberland table-lands. The river hills are mostly of this character.

Farther back, and generally north and northwest of the line of the Memphis and Charleston railroad, it is usual to find the summit of the highlands between the water-courses continuous with that of the great Cumberland plateau of Tennessee. The lower parts of these mountain spurs are usually made up of the calcareous strata of the Mountain Limestone, while sandstones and conglomerates form the upper parts and the summits. A line of sandstone cliffs near the summits makes the ascent of these spurs exceedingly difficult, and in the northern part of the county it is possible to cross the ridges only by making wide detours, following the courses of the streams, ascending the plateau near their headwaters, crossing the level areas on the top, and making the descent along a parallel water-course. Upon these spurs the soil and timber are the same as those of the summit of Raccoon Mountain, described above.*

To recapitulate, the soil-varieties of Jackson county are embraced under the following general heads:

1. The red, brown, and black soils of the hillsides, of the level and rolling lands, and of the river and creek bottoms. The soils of this class are derived from the Mountain Limestone, the lower Sub-Carboniferous, and the Silurian formations. They form the great body of the fertile valley lands, are mostly in a state of cultivation, and hence, from an agricultural standpoint, are the most important. They also rank second as to superficial extent.

2. Light-gray siliceous or flinty gravelly soils, covering some of the creek bottoms and some of the slopes near the foot of the mountains, and also forming the flinty or cherty ridges which run parallel to the river on the northwest side. These are derived from the lower beds of the Sub-Carboniferous and form part of the Lower Silurian formation. They are less important than any other described.

3. The light-yellowish or gray sandy soils which cover the

*The data for much of the description of Jackson county are from Henry McCalley, in Alabama Geological Report, 1879-1880.

mountain plateaus on both sides of the river, derived from the rocks of the Coal Measures, are in superficial extent the most widely distributed, and are gradually coming under cultivation.

Jackson county, like other counties of northern Alabama which have a substratum of limestones, is noted for the great number and boldness of the springs which break up from the fissures in the limestone.

Agriculturally, Jackson resembles Madison, which adjoins it on the west, though a much smaller proportion of its cultivated land is in cotton; but, on the other hand, a much larger proportion is in grain.

ABSTRACT OF THE REPORT OF W. F. HURT, OF BELLEFONT.

(This report refers to the lands drained by Mud creek, a tributary of the Tennessee river.)

On new lands the cotton grows too long and is liable to be cut off by frost, but it can safely be planted on beech and poplar lands when not too much exhausted by cultivation. The black lands are grass and grain lands, but are not suited to cotton. The most important soils are the red lands with red-clay foundations, the gray creek soils, and the barren, gray, gravelly or flinty lands which lie above overflow. Of these only the first is described in detail.

The red lands form about two-thirds of the cultivated area, and, alternating with the gray and black soils, are found throughout the county. The native growth is black and red oaks and hickory on the uplands; poplar, beech, walnut, sweet gum, and white oak on the lower lands. The top soil is a fine sandy or gravelly loam, alternating with a heavier clay loam of brown, mahogany, and red colors, the thickness being quite variable. The subsoil is heavier, and somewhat hard until acted on by rain and air. It generally contains angular, flinty pebbles, and is underlaid at 10 to 20 feet by hard limestone rock.

Lands are generally somewhat difficult to cultivate in wet weather. The chief crops are cotton, corn, wheat, etc., and the land seems equally well adapted to all. Perhaps as much as three-eighths of all the cultivated land is planted in cotton. The average height of fully-grown cotton is about three feet. At this date no land lies turned out, as it is all needed for cultivation. The slopes are not much injured by washings, and the washings from the uplands are beneficial to the valleys.

MARSHALL.

(See "Coal-Measures region.")

MORGAN.

Population: 16,428.—White, 11,758; colored, 4,670.

Area: 700 square miles.—Woodland, all. Coal Measures of Sand Mountain, 275 square miles; Sandy lands of Little Mountain, 140 square miles; Valley lands, 285 square miles (red lands, 100 square miles; coves and slopes, 185 square miles).

Tilled land: 95,584 acres.—Area planted in cotton, 18,828 acres; in corn, 35,610 acres; in oats, 4,704 acres; in wheat, 7,005 acres; in rye, 135 acres; in tobacco, 52 acres; in sweet potatoes, 365 acres.

Cotton production: 6,133 bales; average cotton product per acre, 0.33 bale, 471 pounds seed-cotton, or 157 pounds cotton lint.

In going from the Tennessee river southward through Morgan county one would come upon four terrace-like plains, each with a rather abrupt slope toward the north and a gentle incline southward. These plains would be:

1. The river bottom, with its loose, rich, alluvial soil liable to overflow, and for this reason mostly planted in corn, though some parts are put in cotton.

2. The Valley of the Tennessee, which is from 75 to 100 feet above the river level, and which is a nearly level plain with rich red or brown soils, interspersed here and there with small rocky knolls, crowned with dense groves of post oak, black-jack, and hickory. The greater part of this valley, which has the same general characters here as in Lawrence county on the west, is cleared and under cultivation, and the original timber is represented only by these remnants left on the rocky ground. The width of the valley varies greatly in different parts of the county. Thus, for instance, opposite Whitesburg, in the eastern part, it is only a mile or two from the river to the foot of the Little Mountains on the south side of the valley, and down to the mouth of Flint creek the mountain in many places forms bluffs along the river bank, while near Decatur it is six or eight miles wide, and in places still wider. It will not be necessary to repeat the descriptions already given of other parts of this valley in Lawrence and Colbert counties.

3. From the valley there is an abrupt ascent of 75 to 200 feet, according to location, to the summit of Little Mountain, which is capped with a stratum of sandstone belonging to the upper part of the Sub-Carboniferous formation. This sandstone has been mentioned somewhat at length under Lawrence and Colbert counties, where it occupies a similar position upon Little Mountain. This mountain, in its entire length, owes its existence to the protection against denudation afforded by the bed of sandstone. The soils derived from this rock are sandy and not particularly fertile, as may be seen from the analysis of the soil from near La Grange, given on page 234. Occasionally, where the sandstone has been cut through by erosion, the limestone which lies below it comes to the surface, forming very limy, prairie-like soils, which are very little under cultivation on account of their drouthy nature, due to the proximity of the limestone to the surface and the consequent thinness of the soil. These areas, however, make excellent pastures. A large body of this kind of land has been mentioned under Lawrence county.

4. From the summit of the Little Mountains, and overlooking the Tennessee valley, there is a gradual descent, going southward, to the foot of Sand Mountain, which makes the fourth terrace above spoken of. The distance across from the summit of the Little Mountains to the foot of Sand Mountain varies very greatly. Opposite Whitesburg these Little Mountains are a mere bench on the side of Sand Mountain, from one-half to one mile in width, but it widens toward the west, and in the vicinity of Decatur the distance is ten or twelve miles from its summit back to Sand Mountain. The gentle slope going southward is due partly to the dip of the rocks themselves in that direction, but much more is due to erosion, since the slope is greater than the dip of the strata. In the southern part of the valley thus formed between the two mountains, and beyond the sandy slope of the Little Mountains, the drainage has cut down into the calcareous rocks which underlie the sandstone of the Little Mountains, and the soils produced from the disintegration of these rocks vary considerably in character, some being black, prairie-like soils, similar to that of

the prairie of Lawrence county, already mentioned, and some gray and crawfishy, and not much prized. From a few miles south of Decatur, up the valley of Flint creek, there is a good deal of this level, sticky, gray land, which appears to be derived from some of the deeper-lying, shaly, calcareous strata. Along the bases of the northern slopes of the spurs of Sand Mountain there is a mulatto soil of very considerable fertility.

From this description it will be seen that the valley between the two mountains, which in Lawrence county has fertile red and brown soils similar to those of the Tennessee Valley, in Morgan county, is more or less sandy, except where the streams have cut their channels down into calcareous rocks. It is doubtful whether in Morgan county the streams have anywhere (except in the vicinity of the river) cut down into the strata which form the basis of the red soils of the Tennessee and Moulton Valleys, and this for two reasons: erosion has been probably less effective eastward than westward, and the thickness of the Upper Sub-Carboniferous beds which overlie the strata in question is very much greater in the eastern than in the western part of the Tennessee Valley. Even in the eastern part of Lawrence county the red soils begin to be replaced by the gray and limy soils previously mentioned.

The fourth terrace, as has already been stated, is formed by Sand Mountain, which is a part of the great coal-field, and is capped by the sandstones and other rocks of the Coal Measures, and has always an abrupt slope, and in places a cliff-like slope northward toward the valley, but is nearly level on the top. The height of this summit above the adjacent valley is from 200 to 450 or 500 feet, according to locality, the greatest height being toward the east. In Lawrence and Franklin counties the northern edge of Sand Mountain is comparatively little indented, and forms the water-shed between the Warrior and the Tennessee drainages, except in the case of Big Bear creek. This is the case also in Morgan county as far as the valley of Flint creek. Eastward of that point, however, this rim is deeply indented, and its outline against the valley is formed of mountain spurs separated by deep coves cut far back into the moun-

tain, by the streams. These spurs, like Sand Mountain of which they are a part, are in great measure composed of the calcareous strata of the Mountain Limestone, which is the upper group of the Sub-Carboniferous formation. Overlying these, and forming the summits both of the spurs and of the main mountain, are the sandstones of the Coal Measures. The northward slopes of these spurs, like those of the main mountain, are very steep, and are composed chiefly of limestones, timbered with fine poplar and walnut trees. At the foot of these slopes is usually a strip of half a mile or more in width with mulatto soils locally noted for their fertility. These summits and very gentle southward slopes have commonly sandy soils and a growth of scrubby oaks and short-leaf pine. The spurs which project farthest north have, as a rule, suffered most degradation, and the sandstone has in many cases altogether disappeared, leaving the limestones as surface rocks. In such cases the usual growth of pine is replaced by cedars. Two of these cedar mountains are situated a few miles southward from Somerville, one of them forming one of the boundaries of Cedar Cove. In the eastern part of Morgan county one of the spurs (if it may not even be called the main body of Sand Mountain) extends quite up to the Tennessee river near the mouth of Flint river, and on the opposite side a ridge, which is the continuation of it, reaches far up northward into Madison county.

It will easily be inferred from the descriptions above given that the whole of Morgan county was once formed of the Coal Measures, whose general elevation was that of Sand Mountain; that these measures also formed the surface of the adjoining counties in the Tennessee Valley; and that all the variety now seen in the topography, geological formations, and soils in this region has been brought about by the action of running waters, of which the Tennessee and its tributaries are the present representatives, and which have worn down the surface very unequally, leaving here a portion with nearly its original height, forming the mountains, and cutting down there another portion into channels, forming the present valleys and lowlands. The

soils and productions are similar to those of the counties adjoining.

MADISON.

Population: 37,625.—White, 18,591; colored, 19,034.

Area: 810 square miles.—Woodland, all. Red valley lands, 360 square miles; Barrens, 150 square miles; Calcareous mountain slopes, 100 square miles; Coal Measures table-lands, 150 square miles; Sandy lands on smaller mountains, 50 square miles.

Tilled land: 213,221 acres.—Area planted in cotton, 72,838 acres; in corn, 69,246 acres; in oats, 6,877 acres; in wheat, 12,578 acres; in rye, 174 acres; in sugar-cane, 58 acres; in tobacco, 224 acres; in sweet potatoes, 839 acres.

Cotton production: 20,679 bales; average cotton product per acre, 0.28 bale, 399 pounds seed cotton, or 133 pounds cotton lint.

There are only two geological formations which take any prominent part in the structure of Madison county, the sub-Carboniferous and the Coal Measures; but the former presents three distinct phases, so that the groups of rocks which give rise to well-defined topographical features as well as soil-varieties are practically four in number. The lowermost of these groups is composed of highly siliceous or flinty limestones, which, in disintegrating, produce gray, sandy, or gravelly soils of only medium fertility, and called, in comparison with the soils derived from the next highest series, "barrens". The topography of this region is much varied and generally rugged.

The limestones which make the next group, though still siliceous, are much less so than those below, and yield soils which are far above the average in fertility. These soils are mostly sandy loams, colored deep-red or reddish-brown with iron, and in some localities, where more calcareous, the color is dark to nearly black, like the prairie soils in middle Alabama. By reason of the comparatively uniform composition of these rocks the surface formed by them is a level or gently undulating plain, dotted here and there with small knolls, composed of the flinty portions of the limestone, and usually covered with a dense growth of oaks and

hickories. The great majority of the best farming lands of the Tennessee Valley, on both sides of the river, are of this character.

The next two groups, consisting of the uppermost beds of the sub-Carboniferous formation (called the Mountain Limestone) and the Coal Measures, are usually associated together, the latter occupying the summits and the former the sides of the mountain spurs and, in some localities, the valleys between them. It has already been stated that the strata of the Coal Measures yield light sandy loams of gray to yellowish colors and of only medium fertility. The Mountain Limestone yields a variety of soils—black and limy, mulatto, gray, and light sandy, according to locality and circumstances. All these strata are approximately horizontal, but have a slight dip south and west.

That part of Madison county east of Huntsville is formed by the spurs of the Cumberland Mountains (detached peaks, groups, and ridges), the remnants of that great table-land, continuous in Tennessee, but separated here by valleys. The summits of these mountains are nearly level on top, and are formed of the sandstones of the Coal Measures, and the resulting soils are the light sandy loams before mentioned. On account of their great elevation, 600 or 700 feet above the valleys, and their pleasant climate, the mountain summits are, when accessible, desirable places of summer resort, Monte Sano, near Huntsville, being the summer residence of many of the citizens of that town.

The valleys separating the mountain spurs have mostly calcareous soils, and are derived partly from the mountain limestone, as mentioned, and in the deeper valleys, and those which reach down nearest to the river, from the same beds which make the soils of the red lands of the Tennessee Valley. In the former case the soils are black and sticky, like many prairie soils, but these are not very common. Sometimes they are light gray, crawfishy, and not desirable as farming lands. The mulatto soils of this formation are much the best. As a rule, the soils over the Mountain Limestone are rather thin, as the rock is commonly found along mountain slopes, and, therefore, is much exposed to washing.

The southwestern part of Madison is covered principally by the red or brown soils characteristic of the great Tennessee Valley, and it is, taken all in all, the most desirable portion of the county for farming. In general it is level or gently undulating, with a few isolated mountain peaks, which vary the scenery. The northwestern part of the county is occupied by the barrens. The line between these and the red lands is very sinuous, and strips of red land extend far up into the barrens along the water-sheds, in some cases reaching to the State line. On the other hand, the peculiar soils of the barrens are seen along many of the creeks much farther south than their general limit. This distribution will be sufficiently clearly shown upon the map, and the peculiarities of the three most important soils are well presented in the following abstract. Analyses of red lands, barrens, and gravelly creek-bottom soils from Madison will be found on pages 226 and 228.

Madison may be taken as the banner county of the Tennessee Valley in the production of cotton, both in the percentage of tilled land in cotton and in the number of bales produced. The red valley lands have mostly been long cultivated in cotton and corn, and without any adequate return, which accounts for the comparatively low product per acre.*

ABSTRACT OF THE REPORTS OF THOMAS B. KELLY, OF CLUTTSVILLE, COLONEL W. C. IRWIN, OF HUNTSVILLE, AND GEORGE D. NORRIS, OF NEW MARKET.

(The first of the reports subjoined refers to the lands drained by Limestone creek and its tributaries, and describes the red limestone land, the barrens, and the flint gravel lands; the second refers to the region drained by Indian and Spring creeks, near Huntsville, and describes only the red valley soil; the third relates to the drainage area of Mountain fork and Hester's creek, both tributary to Flint river. The only soil described is the red clay or limestone soil above named.)

The uplands are, in most cases, better suited than the bottoms to cotton culture, as the plant matures better and is less liable to injury from frosts and wet weather. In good seasons, however, the lowlands will yield a larger crop and a better quality of cotton than the highlands. The most important soil is that of the red lands, which make about nine-tenths of the cultivated land in the area embraced by the second report, and about two-thirds of the cultivated area of the other two. The prevailing timber is poplar, walnut, hickory, chestnut, black, post, red, and white oaks, ash,

*For much of the material for the above description of Madison county, we are indebted to Henry McCalley, in Alabama Geological Report for 1879–80.

elm, etc. The top soil is a sandy clay loam of brown, red, and mulatto colors, sometimes nearly black. The thickness varies greatly with locality, being one or two feet deep in the lowlands. The subsoil is a red-clay loam, not impervious, becoming darker, like the top soil, under cultivation, and contains commonly angular fragments of flint or chert, underlaid at a depth of five to ten feet by soft, reddish-stained limestone rock. The barrens make a third of the area under cultivation near Cluttsville, but they extend thence all through the northern part of the county. The timber is chiefly post, black, white, Spanish, and black-jack oaks. The top soil is a fine sandy loam, becoming sticky and putty-like when wet, has usually a whitish to gray color, and is on an average eight inches thick. The subsoil is rather heavier, a yellowish-red sandy material, underlaid with a hard-pan impervious to water at three to five feet. The flinty gravel soil is of limited extent, being found only along the streams. Its natural timber is beech, poplar, sugar maple, and oaks. The character of the soil is indicated in its name; the color, whitish to gray; thickness, about 12 inches. The subsoil is heavier, and is of a yellowish to red color, and contains many fragments of flint. At five to fifteen feet depth it is underlaid with a slaty rock.

Land is easily tilled, in dry seasons especially, the principal crops being cotton, corn, oats, etc. The soils are adapted to several crops, but cotton is the chief production, at least half of the cultivated land being planted with it. The average height to which cotton grows is three or four feet. Very little land now lies turned out. The slopes or hillsides are much injured by washings from rains. This can be prevented or checked by ditching, which is sometimes practiced with success; but the valleys are generally improved by the washings from the uplands.

LIMESTONE.

Population: 21,600.—White, 11,637; colored, 9,963.

Area: 590 square miles.—Woodland, all. Red valley lands, 175 square miles; "Barrens," 415 square miles.

Tilled land: 129,477 acres.—Area planted in cotton, 44,334 acres; in corn, 44,612 acres; in oats, 4,134 acres; in wheat, 7,561 acres; in rye, 234 acres; in tobacco, 107 acres; in sweet potatoes, 417 acres.

Cotton production: 15,724 bales; average cotton product per acre, 0.35 bale, 498 pounds seed-cotton, or 166 pounds cotton lint.

Limestone county resembles Lauderdale in its geological structure, surface, configuration, and soils, and much that has been said under that county will apply here. A line drawn from the middle of the eastern boundary of Limestone county to its southwestern corner will divide it into two portions, differing widely from each other. North of this line are the barrens, the extension into Alabama of the

highlands of Tennessee; south of the line the lowlands of the Tennessee Valley. The average height of the former above the valley lands is not less than two hundred feet, but this increases going northward. The valley lands themselves are some one hundred feet or more above the level of the Tennessee river. Immediately adjoining the river are the first-bottom lands, which are not above overflow. These three terraces (if they may be so called) have their distinctive features. The bottom lands proper are nearly level, and have the usual fertile sandy loam soils, which are much better suited to the production of corn than that of cotton. The valley lands are also nearly level, or only gently undulating, with here and there a rocky knoll covered with timber. The rest of the valley, as already stated, is almost entirely cleared and under cultivation. The rock underlying this portion of the county is a limestone of Sub-Carboniferous age, more or less impregnated in places with chert or siliceous matter. As the rock disintegrates under the influence of the atmospheric agencies, the indestructible flinty portions are left, forming the rocky knolls, which are not generally cultivated, but which often form the sites of the farmers' houses. The soils derived from this limestone are clay loams of red, brown, and almost black colors; and the subsoil is nearly always a heavy, red clayey loam, which assumes the characters of the top soil after cultivation. This rests upon the limestone at depths which vary with the locality, the black soils being those in which the influence of the lime is most strongly felt. These are the true cotton lands, and yield, when fresh, from 1,000 to 1,500 pounds of seed-cotton to the acre. The timber which still remains upon the rocky knolls is composed of the various species of upland oaks, hickory, ash, gums, etc.

These rocky knolls are usually of comparatively small extent. "Nubbin" ridge, however, which seems to have a similar origin, is an exception, for it is quite high and broad, and extends from the near vicinity of the Tennessee river northward to the region of the barrens. The boundary line between this county and Madison runs along the top of this ridge for many miles. The summit of the ridge is much less encumbered with the fragments of chert than

are most of the rocky knolls of similar origin, and there are upon it many spots of fair cotton land. As a general thing, however, the soil seems to be badly worn, and old fields, gashed with gullies and grown up in briers, are more often seen than cultivated lands. On account of the fine water everywhere to be had on the ridge, its pleasant climate, and its elevation, this ridge was once to a greater degree than at present, the place of residence of planters whose farms were situated in the more productive but less salubrious lowlands.

The valley lands are bounded on the north by the foothills of the highlands, and the line of separation is an exceedingly irregular one. The surface of this transition region is much more broken than that of the valley lands on the one side or of the barrens on the other.

In general, the barrens have the characters of a tolerably level plateau, the surface of which has been cut into deep, narrow ravines by the streams. But in this respect the western part of the county is quite different from the eastern. The tributaries of Elk river, on the west, are confined to deep and narrow gorges, and have very little first and second-bottom lands.

In the vicinity of any of these streams, but especially of Elk river, are the river hills, which make a distinct agricultural division. The manner in which they have been formed may be explained by the following considerations: Elk river flows down a basin three or four miles in width, bordered on each side by cliffs, more or less abrupt, of the rocks which form the barrens. The river follows a winding course down this basin, impinging first against the one side and then against the other, leaving on one side only a narrow strip of bottom lands between it and the cliff. On the opposite side, however, the cliffs are some three miles away, and the space between them and the river has been much eroded, and is now dotted with hills having steep sides, sometimes isolated, and covering an area of twenty-five or thirty acres, sometimes connected together by low ridges. There is very little level land on top of these hills, which are the only relics left of the land degraded by the short tributaries of the river. The soil of the hillsides is red and

quite fertile, and generally in cultivation; but the hills have the disadvantage that the soil is very difficult to retain, as it is liable to be washed away by every hard rain, because of the steep slopes. Such are the river hills, which are much desired as farming lands, notwithstanding the natural disadvantages to which they are subject.

In the eastern part of the county the basins of the creeks are shallower, with gently-sloping sides, and include often considerable bodies of very good land. The upper part of Elk river also has some very good tracts of second-bottom land, the river hills being, as a rule, absent in that section, the fertile areas found in these positions among the barrens being in all probability derived from some of the lower and more purely calcareous beds of the generally highly siliceous strata of the lowest division of the Sub-Carboniferous formation. On account of a gentle dip toward the south, these lower beds, composed in the main of very impure siliceous limestones, while they form the surface rocks in all the northern half of the county, in the barrens, in the lower half, pass beneath the purer and less siliceous limestones of the upper division of the Sub-Carboniferous formation which make the valley lands. This valley limestone, however, is never very thick on the northern side of the Tennessee river, at least as far eastward as Decatur; and along the river banks, and in places also along the smaller streams, the underlying rocks of the barrens are exposed in every cliff.

The line of separation of the barrens from the valley lands is, as before stated, quite irregular, for the rocks of the former along the creek basins reach far down into the valley, sometimes even to the river, while on the other hand, the red soils of the valley may frequently be found upon the summits of the dividing ridges, reaching up into the barrens for long distances. The town of Athens stands upon one of these prolongations of the red lands, and in the northern part of the county there are a few isolated spots of this red land still left upon the higher summits.*

Agriculturally, Limestone is like Madison county, except

* Most of the above details are from Report of Henry McCalley, Alabama Geological Survey Report, 1879-80.

that in Limestone there is a smaller proportion of red valley land, and a larger proportion of barrens. The area planted in cotton yields an average return, although the majority of the lands are much worn, and have had comparatively little help from fertilizers.

ABSTRACT OF THE REPORT OF F. H. PEEBLES, OF MOORESVILLE.

(The region referred to is drained by Piny, Limestone, and Beaver Dam creeks, all tributaries of the Tennessee river.

The two principal soil-varieties described are the red-clay lands and the light, sandy bottom lands of the Tennessee, and only the red lands are mentioned in detail. These form about ninety per cent. of the area reported upon, and the natural growth is composed of ash, hickory, gum, and species of oaks. The greater part of the timber has been removed, and the land brought under cultivation. The top soil is a red-clay loam, as a rule, though other colors are noticed. The average thickness is four inches, and the subsoil is heavier, but of the same general character with the soil. It contains, especially near the water-courses, rounded and angular pebbles of quartz and chert.

Tillage is easy, except directly after hard rains, or in excessively dry seasons. The chief crops are cotton and corn, and the soil is about equally well suited to each. A little more than half the area is put in cotton, which grows to a height of from one to six feet, being most productive at three feet. About one-tenth of the land originally cultivated is turned out, but when again taken into cultivation, it produces very well. There is comparatively little injury from washings, either to the uplands or the valleys.

LAUDERDALE.

Population: 21,035.—White, 14,173; colored, 6,862.

Area: 700 square miles.—Woodland, all. Barrens, 400 square miles; Red valley lands, 200 square miles; Gravelly hills, with short-leaf pine, 100 square miles.

Tilled land: 102,839 acres.—Area planted in cotton, 26,594 acres; in corn, 42,890 acres; in oats, 4,609 acres; in wheat, 8,475 acres; in rye, 262 acres; in tobacco, 105 acres; in sweet potatoes, 467 acres.

Cotton production: 9,270 bales; average cotton product per acre, 0.35 bale, 498 pounds seed-cotton, or 166 pounds cotton lint.

To present in a satisfactory manner the topography and soil distribution of Lauderdale county, it will be necessary to refer to its geological structure. The entire county is immediately underlaid with the rocks of the Sub-Carbonifer-

ous formation and with the lower strata of the same. These are of two sorts, the upper beds being more calcareous and the lower more flinty or siliceous, and the soils derived from them vary accordingly. All these beds have a gentle slope or dip southward, by which circumstance the lower or more siliceous beds, while forming the immediate surface in the northern part of the county, are in the vicinity of the Tennessee river at considerable depths below the surface, which is formed of the underlying more calcareous rocks. The areas where these two classes of rocks form the surface differ widely in their topography, soils, and other features.

The northern part of the county (five-sevenths), formed by the siliceous beds, is an elevated plateau, a part of the Highlands of Tennessee; the southern part (two-sevenths), where the calcareous beds make the surface, is a portion of the great Valley of the Tennessee.

The first of these two areas is called the Highlands, or Barrens, and it may be described as a high plain, much cut up by deep, long, narrow ravines, which extend north and south, and from which branch off other smaller ravines, all occupied by streams during the winter months. This area becomes more broken and rugged southward, where on the borders of the valley land it is cut up into a maze of hills and ridges, with hollows or coves between, across which—*i. e.*, east and west—it is almost impossible to construct a passable road. The broken character of the country and the formation of the deep, narrow ravines, with nearly perpendicular sides, are due to the comparatively indestructible rock which lies near the surface. The disintegration of this rock, which is a highly siliceous limestone, in places almost a flint rock, gives rise to the formation of the barrens soil, a light-gray siliceous soil, which, as compared with the valley soils, is rather poor, but, as analysis and practice both show, by no means merits the name of barrens. The characteristic timber consists of post and black-jack oaks and short-leaf pine. To these are added other trees, according to variations of the soil. Along the creeks and ravines are found the finest white and red oaks, poplars, chestnuts, etc. These lands have always considerable elevation above the sea (250 feet above the level of Tennessee river, increasing

toward the north). There is comparative immunity from malarial disease, the soils are more easily worked, and the cotton matures earlier, and gives often a better staple. For these reasons the lands of the barrens are gradually being brought into cultivation. Analyses of soils of this kind from Madison county have been given (see page 226).

The second of the areas above mentioned is known as the Valley of the Tennessee, and constitutes in Lauderdale county a strip of gently undulating, nearly level land about 100 feet above the river and some four or five miles wide. The line separating this from the highlands is very irregular, especially in the western part of the county. The valley soils vary from red or brown loams to a dark or nearly black calcareous loam. They are all fertile and stand cultivation well, some of them having been tilled for the past seventy-five years (practically without manure) and yielding at the present day tolerably fair cops. The natural growth consists of the various species of oaks and hickories, but most of the best lands have long since been denuded of their native forests. The limestone, which forms the substratum of the valley lands, is, in general, somewhat siliceous though sometimes quite pure, the less pure or more siliceous portions of the limestone, in disintegrating, giving rise to the formation of rocky knolls, which are usually covered with the orignal timber, and form agreeable interruptions to the otherwise somewhat monotonous scenery. On these knolls frequently stand the houses of the planters. A marked feature of the valley region which is underlaid with this limestone is the great abundance of big springs and sink-holes.

The drainage of Lauderdale county is all southward into the Tennessee river by streams which have their headwaters in the Highlands of Tennessee. Some of them have cut down through the limestones of the country into the rocks of still older formations, though these take no part in the formation of the soils.

In the western part of the county the calcareous rocks above mentioned are covered with beds of varying thickness of pebbles and sand of the Stratified Drift formation. Where these beds form the surface, they give rise to the

formation of soils of the kinds often previously described. A conglomerate or sand stone made of these materials, cemented by iron, is of frequent occurrence in this part of the county. The ridges, which have generally a more or less sandy soil, are timbered with post oaks and short-leaf pines. Some of the springs of the county have a reputation for medicinal properties, the best known of these being Bailey's Springs, not far from Florence. West of the town of Florence, in the great bend of the river, is the largest body of valley land in the county. It is known as the Colbert Reservation, and embraces some fine farms. The valley land is said to produce, when fresh, as much as 1,000 pounds of seed-cotton to the acre, and is excelled by few tracts in the county. The yield of the better class of barrens in seed-cotton is given at 600 pounds. From the character of the topography, the bottom lands within the region are quite narrow.*

By far the greater proportion of the cotton of Lauderdale county is produced upon the red valley lands, which form a good deal less than one-half the area of the county. The product per acre is above the average, and the percentage of tilled land in cotton is also quite high.

ABSTRACT OF THE REPORT OF JAMES WILLIAM MORGAN, OF FLORENCE.

(*This report refers to the valley lands and river bottom in the Colbert Reservation.*)

The lowland cotton is liable to rust and shed in wet seasons, and is more likely to be killed by early frosts than that planted in the higher valley lands. For these reasons very little of the bottom lands is cultivated in cotton in the region under discussion, corn being the universal crop. The valley lands proper, about one hundred feet above the river level, are the cotton lands. The soil varies with the location. The timber consists of hickory, post, black, red, and black-jack oaks, poplar, dogwood, etc. The top soil is a fine sandy or gravelly loam of a yellowish-brown to orange-red color, twelve to eighteen inches in thickness, resting upon a tough reddish-clay subsoil, which, when undisturbed, is quite impervious. It contains numerous angular fragments of flint or chert, remnants of the siliceous portions of the limestone rock which underlies the subsoil at a depth of eight to ten feet on an average.

Land is generally easily tilled in dry seasons. The chief crops are cotton, corn, wheat, oats, sorghum, and sweet potatoes, and all these crops are good under favorable surroundings. At least two-thirds of the land,

*See Report of Henry McCalley, Alabama Geological Survey Report for 1879-80.

however, is planted in cotton. About one-third of the land is turned out, which, when reclaimed, produces very well if not too much washed. The slopes or hillsides are sometimes seriously damaged by washings; but the valleys are sometimes injured, sometimes improved, by the washings of the uplands--depending on the character of the deposit. Circling and ditching to some extent prevent injury to hillsides from rains.

LAWRENCE.

Population: 21,392.—White, 12,642; colored, 8,750.

Area: 790 square miles—Woodland, all. Red valley lands, 260 square miles; Calcareous land along mountain slopes and in coves, 220 square miles; Sandy lands of Little Mountain, 150 square miles; Coal Measures, 160 square miles.

Tilled land: 138,034 acres.—Area planted in cotton, 42,803 acres; in corn, 54,643 acres; in oats, 5,691 acres; in wheat, 5,919 acres; in rye, 117 acres; in tobacco, 105 acres; in sweet potatoes, 379 acres.

Cotton production: 13,791 bales; average cotton product per acre, 0.32 bale, 456 pounds seed-cotton, or 152 pounds cotton lint.

The plateau of the Warrior coal-field terminates in the lower part of Lawrence county, in a mountain escarpment 250 or 300 feet in height overlooking the Moulton Valley. This mountain forms the divide between the waters flowing into the Tennessee and those flowing into the Warrior river. Between Moulton and Courtland there is another range (called the Little Mountain) running east and west. This ridge is cut by all the streams flowing north into the Tennessee, and separates the Moulton Valley on the south from the Tennessee Valley on the north. The county is thus divided into four belts: two with prevailing sandy soils, formed by the two mountain ridges, and two with calcareous soils, occupied by the two great valleys mentioned. The geological formations which enter into the structure of the county are the Sub-Carboniferous and the Coal Measures. The rocks of the latter are found only upon the summit of Sand Mountain, and therefore only in the southern part of the county, while the Sub-Carboniferous rocks underlie the rest of it. The soils of Sand Mountain, like those of the Coal Measures generally, are sandy loams of no great fer-

tility, but, holding well all fertilizers, are coming much into notice lately.

The Sub-Carboniferous rocks, while mainly limestones, have near the top of the series a bed of sandstone of considerable thickness and of great importance in the topography and soil formation in this and adjoining counties; for the Little Mountain range owes its existence to the protection afforded by a capping of this rock against the denuding forces which carved out the two valleys which it separates. The main body of the Little Mountain is made up of limestones, which are passed over in ascending the mountain from either side, and it is only the summit that is occupied by the sandstone. The soil derived from this rock is a sandy loam, an analysis of which from LaGrange, Colbert county, is given on page 234, and it supports the usual growth characteristic of sandy soils, viz: short-leaf pine and post and black-jack oaks. In some places the sandstone is absent over considerable areas on the summit of the mountain, and the underlying limestones makes the surface forming limy or prairie soils. A tract of this prairie land about a mile and a quarter wide and 15 miles long extends along this mountain from the western part of the county a mile or less into Franklin county. This is a level piece of land, mostly uncultivated, but thickly carpeted with grass, through the soil of which in many places the bare limestone rock protrudes. Where the soil is deep enough it is said to be well suited to the cultivation of wheat, which comes to maturity before the dry weather of the summer sets in; to other crops this land is not suited, since, on account of the proximity of the underlying rock to the surface, the soil suffers much from drouth. Throughout this prairie are scattered groups of trees, which afford good shade to cattle, and thus enhance the value of the land as pasture grounds. The characteristic growth is persimmon, haw, cedar, gum, and honey-locust. Along the sides of the mountain it is not uncommon to find narrow ledges with level surface of this kind of soil.

Both the great valleys in this county have flinty limestones for a substratum, and the soils and topography are determined by these rocks. The valley in which Moulton

is situated is about five miles wide, and extends nearly through the county, merging into the mountain lands toward the east, but being more open toward the west. The Valley of the Tennessee has the same general characters, but is wider and much more uniform in its features, and is, in general, a level plain with a red sandy loam soil of great natural fertility. The greater part of this plain is under cultivation, but the cleared lands are dotted here and there with beautiful groves of hickory and oaks, which cover the rocky knolls made by the disintegration of the more siliceous portions of the valley limestone. As already stated, these knolls are often selected as building spots, and many of them are adorned with handsome houses. Toward the river the valley limestone thins out, and along the banks of that stream the siliceous rocks which underlie it are exposed in bluffs of considerable height. The general level of the great valley may be put at about 100 feet above the river. The Tennessee bottom lands are loose sandy loams, very productive, but in general better suited to the production of corn than to that of cotton.

The outline of the Little Mountain against the Tennessee Valley is very irregular, and is a succession of projecting mountain spurs, often with a face of nearly perpendicular cliffs, alternating with limestone coves. Near the heads of these coves are sometimes found scenes of great wildness and beauty. In all the valley the lands are much worn from continuous cultivation, without return.

ABSTRACT OF THE REPORTS OF COLONEL JAMES E. SAUNDERS AND DR. F. W. SYKES, OF TOWN CREEK.

(The region described is that drained by Town and Big Nance creeks.)

This region is less liable to be visited by the caterpillar, and is also less liable to failures of the cotton crop by reason of wet weather, than are the cotton lands farther south. On account of the sandy nature of the soil the crops mature better in the Tennessee Valley than in regions with a different soil. Better average crops are made here than in the rich black canebrake belt farther south. The chief soils of the valley are the level uplands, the sandy creek bottoms, and dark sandy bottom lands of the Tennessee river. Of these only the first will be described in detail. This forms nine-tenths of the cultivated lands of the valley, and was originally timbered with post oak and hickory, and some black-jack oak; later a growth of red oaks has sprung up. The top soil is a fine sandy ferruginous

loam of a mahogany to reddish color, with an average thickness of six inches. The subsoil is heavier, being a clayey loam of a dark-red color. It bakes hard when ploughed too wet, yet it crumbles readily when exposed to the rain, and holds fragments of chert, rounded and angular, and full of the impressions of fossils. The subsoil is underlaid with a limestone rock at 10 to 20 feet depth.

These lands are easily cultivated in both wet and dry seasons. The chief crops are cotton and corn, two-thirds of the land being devoted to the former. In rich soil cotton grows five or six feet high, but is generally most productive when three feet in height. About one-tenth of the land originally cultivated is turned out; but when reclaimed, it produces well if manured and properly cultivated. Uplands are much damaged by washings.

COLBERT.

Population: 16,153.—White, 9,203; colored, 6,950.

Area: 570 square miles.—Woodland, all. Gravelly Hills, 250 square miles; Sandy soils of the Little Mountain, 170 square miles; Red valley and other calcareous soils, 150 square miles.

Tilled land: 64,876 acres.—Area planted in cotton, 25,411 acres; in corn, 31,575 acres; in oats, 3,846 acres; in wheat, 1,704 acres; in rye, 69 acres; in tobacco, 34 acres; in sugar-cane, 15 acres; in sweet potatoes, 286 acres.

Cotton production: 9,012 bales; average cotton product per acre, 0.35 bale, 498 pounds seed-cotton, or 166 pounds cotton lint.

East and west through Colbert county runs a range of hills called the Little Mountain, north of which lies the Valley of the Tennessee and south, Russell's Valley. Toward Russell's Valley the slopes of these hills are covered with thick beds of pebbles, but toward the Tennessee Valley the mountain sinks down rather abruptly, leaving an escarpment not covered by pebbles. The Little mountain is composed entirely of the strata of the sub-Carboniferous formation, which also form the substratum of the valleys on each side. These strata are, in the main, limestones, with a bed of sandstone of considerable thickness near the top of the series. This bed of sandstone forms the summit of the Little Mountain, which owes its present elevation above the valleys to the protection against the denuding forces afforded by this rock. The average height of the mountain above the valleys is some 300 or 350 feet.

All the streams of the county flow into the Tennessee, and all have their sources in the mountains south of Russell's Valley, in Franklin county. In their courses toward the Tennessee they have, especially westward, cut gorges or small cañons into the sandstones which form the upper stratum of the Little Mountain. After leaving the mountain, they flow through the comparatively level valley toward the river. In these mountain gorges are many scenes of wild and rugged beauty; and it is not strange that the chalybeate springs, which are so common here, have been favorite places of resort.

The soils, which have been derived from the sub-Carboniferous rocks, are of two kinds, sandy and calcareous. The former are, as a rule, found upon the summit of the Little Mountain; the latter in the valleys. The general characters of the sandy soils may be learned from the analysis given of a soil from LaGrange (page 234). The calcareous valley soils are of two principal sorts, according to the locality: (1) Over most of the valley the soil is a reddish loam, with yellowish or reddish clay subsoil, and where the soil is directly upon the limestone, and much affected by it, the color is inclined to be dark to black, like highly calcareous soils of other regions. (2.) In the bottoms and lowlands generally the soils are looser and more sandy or gravelly. The valley lands are timbered with a fine growth of oaks and hickories, and make an attractive country. The sandy mountain lands are timbered chiefly with post oaks and short-leaf pines.

Pebbles and beds of Stratified Drift cover all the western part of the county within eight or ten miles of the Mississippi line, and the soils, derived altogether from these beds, are very little, if at all, affected by the underlying calcareous strata of the sub-Carboniferous formation. In all this part of the State sandstones and conglomerates are of frequent occurrence, formed by the cementing together, by hydrated oxide of iron, of the sands and pebbles of the Drift. Nearly every hill or ridge has upon it a capping of this sort of rock. Pine (short-leaf) and post oak form the prevailing timber on all these gravelly and sandy lands. As previously stated, the beds of drift cover also the southern slopes of the Little

Mountain, toward Russell's Valley, as far east as Frankfort. In this respect Russell's Valley differs from that of the Tennessee.

Analyses of the Tennessee Valley soil and of the gravelly or river hills soil have been given on pages 231 and 234, and they, together with the analysis of the mountain soil from LaGrange, exhibit the characters of the principal soils of Colbert county.

Colbert differs from the other counties of the Tennessee Valley, except Franklin and Lauderdale, in the circumstance that a considerable portion of its soils is made by the Drift, and they are, to a certain extent, independent of the underlying rocks of the country.

ABSTRACT OF THE REPORTS OF L. B. THORNTON, OF TUSCUMBIA, AND OF T. B. BICKLEY, OF SPRING VALLEY.

(These reports refer to the valley lands within 10 *or* 15 *miles of Tuscumbia.)*

The higher-lying lands of the valley are best suited to cotton, which in the flats or basins is liable to injury from wet seasons and early frosts. These higher lands are excellent farming lands, and there is scarcely ever a failure in the crop. As usual, wet seasons, late, cold springs, and early frosts are circumstances of climate which interfere with the growth of the plant.

The principal soil-varieties are brown loam, with red-clay subsoil, and the sandy mountain soil. The former, with its many variations, forms the greater part of the Tennessee Valley within the county limits; the latter is found in all the mountainous regions in the southern portion of the county. The prevailing timber upon the brown-loam lands is made up of red, white, black-jack, post, and chestnut oaks, hickory, chestnut, black walnut, and gums. The soil is a clayey loam of a brown to nearly black-color, one to two feet in thickness, with a subsoil of red clay, which becomes like the surface soil upon cultivation, and both soil and subsoil frequently contain angular fragments of the flinty or cherty portions of the rocks from which they are derived. The subsoil rests on limestone rock at depths varying with the locality and is porous, and all these lands are naturally well drained. The mountain lands have a growth of chestnut, post, white, and chestnut oaks, with short-leaf pine. The soil is a coarse, sandy loam of a whitish to gray color, and quite thin. The subsoil is rather heavier, and contains occasionally rounded pebbles of quartz and fragments of the underlying rock, which is a sandstone, and usually at no great depth from the surface.

Land is somewhat difficult to cultivate in wet seasons, but can be tilled early when well drained. The principal crops are cotton, corn, wheat, oats, clover, and potatoes, and all succeed well. About one-half of the valley and one-fourth of the mountain land are planted in cotton. The usual height of the plants is from three to five feet in the valley and two feet on the mountain, production being most rapid just before growth is completed.

At least one-third of the valley and one-half of the mountain land originally lying in cultivation is now turned out, but when restored to cultivation it generally produces about as well as fresh land. The slopes or hillsides are washed into gullies unless measures are adopted to prevent washing, but the valleys are often benefited by washing from the uplands.

FRANKLIN.

Population: 9,155.—White, 8,079; colored, 1,076.

Area: 610 square miles.—Woodland, all. Red valley and other calcareous lands, 220 square miles; Sandy soils of the Little Mountain, 40 square miles: Gravelly hills, 200 square miles; Coal Measures, 150 square miles, in great measure, however, covered with Drift.

Tilled land: 46,895 acres.—Area planted in cotton, 10,368 acres; in corn, 21,038 acres; in oats, 3,020 acres; in wheat, 1,660 acres; in tobacco, 17 acres; in sugar-cane, 96 acres; in sweet potatoes, 137 acres.

Cotton production: 3,603 bales; average cotton product per acre, 0.35 bale, 498 pounds seed-cotton, or 166 pounds cotton lint.

The northern half of Franklin county is a valley known as Russell's Valley; the southern half is high table-land, the northern edge of the Warrior Coal-field. Most of the streams of this county rise at this foot of the escarpment which separates the valley from the table-land and flow northward into the Tennessee. Big Bear creek takes its rise south of this escarpment and flows at first southwestward, as though a tributary of the Tombigbee, but its course is soon changed to westward and then northwestward by an accumulation of pebbles and sand, and it breaks through this mountain escarpment into the valley and flows thence northward into the Tennessee. This pebble ridge is a noticeable feature in the topography of Franklin county. Overlying the strata of the Coal Measures, it forms an irregular crescent, beginning in the southeast of Franklin, bending down into Marion, and returning again into Franklin county near its southwestern corner. The waters north of this ridge flow into the Tennessee; south of it into the Tombigbee. The extraordinary deflection of Big Bear creek, caused by this ridge, has been mentioned under Marion county. The waters of Big Bear creek, on the north, are

some fifty feet or more higher than those of the tributaries of the Tombigbee river on the south, though the two are only a few miles apart.

The geological formations concerned in the structure of Franklin county are three in number, viz: the Sub-Carboniferous, the Coal Measures, and the Stratified Drift, and their surface distribution is in general as follows: The table-lands are formed by the second, the valley by the first, while the Drift overlies both in the western part of the county, and to some extent also in other portions. To go more into detail, the northern limit of the Warrior field is an exceedingly irregular line, formed by projecting ridges, with limestone coves between. East of Russellville these mountain prongs extend northward as far as the middle of township 7, and a few project still further northward. West and southwest of Russellville the line is still less regular, and cannot well be described without the aid of a detailed map. The irregular line of mountain spurs, with interlocking coves, runs from Russellville south and southwest to near the middle of township 8, range 14 west, and thence southward into Marion county. Except near the southern line of the county the strata of the Coal Measures are found only near the summit of the mountain, and are therefore of no great thickness, the sides of the mountain, as well as the valley below, being formed of the calcareous rocks of the Sub-Carboniferous formation.

The soils derived from the disintegration of the strata of the Coal Measures are, as usual, sandy and not very fertile, but the calcareous rocks above mentioned give rise to soils which are above the average in fertility. The soils of the drift have already been frequently described. The best cotton lands are found in Russell's Valley, and the soil best suited to this crop is a red or mulatto-colored loam with red or yellow clay subsoil. Where the limestone reacts upon the soil, this is often of a black color, much like the black prairie soils of the lower part of the State. The deep color is due to the presence of vegetable matter and its rapid decay under the influence of the lime. The bottom lands partake, as usual, of the characters of the uplands from which they are derived, but are, as a rule, rather more

sandy. In the western part of Franklin county the beds of Stratified Drift overlie the other formations, and the soils are derived from the loam and other strata of this superficial covering. In the eastern part of the county the table-lands before spoken of are about 250 or 300 feet above the general level of the valley, but westward the height decreases somewhat, and the escarpment which forms the southern limit of the valley loses its importance west of Russellville, both because of the diminished height of the escarpment itself and because the beds of Drift have filled up the valley.

In cotton product per acre Fanklin ranks well with the Tennessee Valley counties, and its soils, both those of the red valley lands and those derived from the Drift, are well suited to the production of this staple.

ABSTRACT OF THE REPORT OF DR. DANIEL N. SEVIER, OF RUSSELLVILLE.

(This report treats of the region drained by Cedar creek, a tributary of Big Bear creek.)

The uplands here referred to are in the valley, and not upon the table-land, and are hilly, with thin soil, mixed with sharp, angular fragments of flint and cherty gravel. This soil has a red or a buff clay subsoil. Either cold or wet injures the growth of cotton, causing it to die out or become lousy. Protracted wet spells cause it to shed its squares, and early frosts kill the top bolls. Hot, dry weather is best for cotton. No damage is done by the caterpillar or boll-worm in this part of the State.

The four principal soil-varieties are, in the order of their importance in cotton cultivation, the red or mulatto lands, the hilly lands, with thin soils and red or buff-colored clay subsoils, the black sandy alluvial lands, and the black lime-lands. The red or mulatto lands are much the best for cotton. They form most of Russell's Valley, which is from six to eight miles wide, and extends from the adjoining county on the east to seven miles west of Russellville. The prevailing timber is red, white, and black oaks, poplar, hackberry, black walnut, cherry, and hickory. The soil is a coarse sandy or gravelly loam, sometimes a heavier clay loam, of buff to brown or nearly black color. The thickness is ten to fifteen inches, and the subsoil a red or buff clay. When well plowed this soil produces good crops and stands drouth well.

The hilly land produces good crops both of cotton and of corn, and other crops as long as it lasts, and it rests upon a red or buff clay foundation, but washes badly into deep gullies, and the lowlands are filled up with great heaps of gravel. The black sandy alluvial lands are subject to overflow, and are well suited to corn, but not to cotton. The black lime-land is also well suited to corn, but the cotton grows too rank upon it, and is likely to take what is called the black rust. In some localities this land rests upon a

bed of limestone at varying depths. These lands are alluvial in character. The chief productions are cotton, corn, oats, and potatoes, but the soils are generally best adapted to the two crops first named. About two-thirds of the red land is planted in cotton, the plants attaining a height of from one to three feet, and usually producing more or less according to the height. The slopes are much damaged by washings, and not much effort is made to prevent or check the injury.

OAK AND HICKORY UPLANDS, WITH SHORT-LEAF PINE.

This region includes the following counties, wholly or in part: Lauderdale,* Colbert,* Franklin,* Marion, Lamar, Fayette, Walker,* Pickens, and Tuscaloosa.*

LAUDERDALE.

(See "Tennessee Valley region.")

COLBERT.

(See "Tennessee Valley region.")

FRANKLIN.

(See "Tennessee Valley region.")

MARION.

Population: 9,364.—White, 8,841; colored, 523.

Area: 810 square miles.—Woodland, all. Coal Measures, 660 square miles; Gravelly Pine Hills, 150 square miles. (The Drift makes a certain proportion of the soils and subsoils over the entire county, but on the west the underlying formations are completely hidden.)

Tilled land: 42,925 acres.—Area planted in cotton, 7,269 acres; in corn, 21,835 acres; in oats, 2,321 acres; in wheat, 3,925 acres; in tobacco, 44 acres; in sugar-cane, 15 acres; in sweet potatoes, 477 acres.

Cotton production: 2,240 bales; average cotton product per acre, 0.31 bale, 441 pounds seed-cotton, or 147 pounds cotton lint.

The area drained by the Buttahatchie river and its tributaries includes the greater part of Marion county. The head-

waters of this stream rise at the western foot of a ridge of sand and pebbles known as Byler Ridge, which extends from Tuscaloosa county northward through Fayette, Walker and Winston counties to the southern limit of the great Valley of the Tennessee. Another ridge of similar structure, but much smaller, in the northeastern corner of the county, turns the waters of Big Bear creek to the north. Most of the tributaries of the Buttahatchie river, in Marion county, flow southward from this ridge, as do also the tributaries of Bull Mountain creek, in the northwestern corner of the county. The bed of Big Bear creek is considerably higher than that of the head-waters of Buttahatchie river and of Bull Mountain creek, which are distant from it only a few miles, and a comparatively short canal would suffice to turn the waters of Big Bear creek in a torrent into either of the others.

The geological structure of Marion county is, in its general outline, quite simple, its substratum being formed of the sandstones, shales and conglomerates of the Coal Measures, which are covered with a capping of pebbles, sand, and other beds of the Stratified Drift. The general slope of the underlying beds is toward the southwest, and the thickness of the superficial deposits increases in the same direction. In the eastern part of the county, even the smaller streams have cut their channels through the thin drift-covering into the underlying Coal Measures, but in the extreme west none but Drift beds are exposed, even in the deepest drainage cuts.

The soils in the west are, in consequence, derived almost exclusively from the overlying Drift beds, and are of the usual characters so often described. The uppermost twenty or twenty-five feet are usually formed of a stiff red loam, which rests upon the beds of pebbles and sand, which make up the greater part of the formation. The red loam, therefore, commonly occupies the higher table-lands and the level second bottoms, where erosion has been least effective. Upon the hillsides and slopes the other beds of the Drift come to the surface, and the soils derived from them are much less fertile. The surface soil of the red loam is usually a sandy loam of a brown color, from the addition of

vegetable matter, and the growth upon it is that of the brown-loam uplands everywhere.

The high table-lands of Marion county furnish superior farming lands, desirable on account both of the natural fertility of the soil, and of their favorable position with respect to drainage, etc. In those parts of the county where the strata of the Coal Measures are near the surface, the sandstones and conglomerates form bluffs in all the ravines. Underneath the overhanging cliffs, or "rock houses," as they are locally termed, grow abundantly some of our rarest and most beautiful ferns, such as *Trichomanes radicans*, *Asplenium pinnatifidum*, *Asplenium montanum*, *Trichomanes Petersii*, etc.

Many of the upland soils, especially in the western part of the county, are quite productive, and with better facilities for shipping the crop, Marion would take a fair rank among the northern counties in the production of cotton.

ABSTRACT OF THE REPORT OF MARTIN NESMITH, OF PIKEVILLE.

(This report refers to the lands drained by Beaver creek, a tributary of the Buttahatchee river.)

Two-thirds of this area is hilly, and is not in cultivation; the remaining portion table-lands and bottoms. The soils, more than the climate, influence the growing of the cotton, for in the low, wet lands the plant weeds well, but does not mature. The uplands and second bottoms, especially when well fertilized, make the best crops, and the plant matures well, the staple being both longer and better. The soil-varieties described are the brown-loam lands, the black sandy lands, and the swampy or low marshy lands.

The first forms one-half or more of the cultivated lands in the region described, and it is timbered with white, black, and red oaks, hickory, short-leaf pine, beech, and black and sweet gum. The soil is a dark or brown sandy loam of five or six inches in thickness, resting on a reddish clayey subsoil, which is underlaid with sand and gravel.

The black sandy lands form one-third of the cultivated lands in the region, and this soil occurs in patches of from twenty-five to thirty acres, alternating with flinty or gravelly lands. The natural growth is short-leaf pine, hickory, post and red oaks, and chestnut. The soil is a sandy or gravelly loam, heavier clayey loam in places, of an average thickness of six inches; the subsoil a tough, whitish clay, which bakes very hard, and does not pulverize under cultivation. It contains often white, rounded, and angular pebbles, and rests upon beds of sand and gravel at a depth of three or four feet.

The swamps or marshes form the third variety of land, and occupy about

one-sixth of the area. The timber is composed of white oak, sweet and black gum, beech, poplar, bay, etc., and the soil is a whitish or gray clayey loam, quite thin (two inches), with a subsoil of heavy clay. This soil, being very thin and whitish, is poor, and does not pay to cultivate.

Tillage is usually difficult only in wet seasons. The principal crops are cotton and corn, the soil being generally best adapted to the former crop. About one-half of the land is planted in cotton, which attains a height of from two to five feet. About one-fourth of the land originally cultivated now lies turned out; but when such land has lain idle several years, it will produce good crops. There is some hillside ditching, to prevent gullies, but the valleys are generally benefited by washings from the uplands.

LAMAR.

Population: 12,142.—White, 9,967; colored, 2,175.

Area: 590 square miles.—Woodland, all. Gravelly hills, 550 square miles; Coal Measures, 40 square miles.

Tilled land: 62,141 acres.—Area planted in cotton, 15,245 acres; in corn, 28,303 acres; in oats, 4,139 acres; in wheat, 5,627 acres; in rye, 75 acres; in tobacco, 46 acres; in sweet potatoes, 626 acres.

Cotton production: 5,015 bales; average cotton product per acre, 0.33 bale, 471 pounds seed-cotton, or 157 pounds cotton lint.

Lamar county is wholly upon the belt of Stratified Drift which covers the line of junction of the older and newer formations in Alabama. Its surface, therefore, is formed by the sands, clays, and pebble beds of this formation and of the rocks which are produced by the cementing together, by hydrated iron oxide, of these materials. A bed of varying thickness of red loam or red clay nearly always forms the surface unless removed by denudation. The soils, consequently, vary from stiff reddish loams, becoming brown upon the addition of vegetable matter, to light sands. The natural growth varies similarly from the luxuriant timber of the oak uplands to that of the black-jack ridges, which, in addition to the oak, often support a growth of short-leaf pine.

From observations made in the adjoining counties, it seems probable that the strata of the Coal Measures underlie the beds of Drift; but as yet these rocks have not been noticed. The hills separating the streams in the eastern part of the county are from 250 to 300 feet in height above

the water-courses, and are composed throughout of the material of the Drift. Pebbles are found as usual below the capping of red loam, which here, as elsewhere, forms the surface. Where thin beds of clay underlie the loam or other strata it is not unusual to find a thin layer of ferruginous sandstone or conglomerate, formed by the cementing together of the sand or pebbles by the oxide of iron which is so universally diffused through this formation as coloring matter. The somewhat hard rocks formed in this way often protect from denudation the underlying strata, and are commonly found upon the summit of the hills, which owe their existence to the protection thus afforded.

The drainage of Lamar county is southwest into the Tombigbee by the Buttahatchie river and Luxapolila creek and their tributaries. The main water-sheds are usually table-lands with brown-loam soils and reddish subsoils, such as have been described at length under Pickens and other counties. The average height above drainage of the table-lands, like that of the highest hills of the minor water-sheds, is some 250 or 300 feet.

ABSTRACT OF THE REPORT OF GEORGE E. BROWN, OF CANSLER.

(This report refers to the region drained by Beaver creek and Buttahatchie river and their tributaries.)

In the second bottoms cotton yields more to the acre than upon the uplands, but is liable to be cut off prematurely by frosts. Throughout the county the soils are more or less sandy in texture, and are timbered with short-leaf pine, the various species of oak, hickory, ash, chestnut, and sassafras. The top soil varies from light sandy to a rather stiff clay loam of whitish, yellow, red, and blackish colors, and the subsoil is usually somewhat heavier, and of a reddish to yellow color, containing pebbles in size from a buckshot up. The subsoil rests on a clay, and this on beds of pebbles and sand. The lands are easily tilled under all circumstances, and the chief crops are corn and cotton. It is thought that corn succeeds best, though the soil is well suited to each.

Nearly half of the tilled land is in cotton, which attains heights varying from three to six feet, being most productive at medium heights. About one-eighth of the land originally in cultivation now lies turned out. If not hilly, such land, when reclaimed, produces about as well as when fresh. The soil is of such a nature that it washes badly on slopes, though the injury from this cause is not very great. If the valleys are very narrow, they are injured by being covered with sand, but no serious efforts have been made to check this evil.

FAYETTE.

Population: 10,135.—White, 8,873; colored, 1,262.

Area: 660 square miles.—Woodland, all. Coal Measures, 600 square miles; Gravelly Pine Hills, 60 square miles, (but the gravel and other Drift beds overlying the Coal Measures to some extent over the entire county, it is only in the 60 square miles above noted that they hide completely the lower rocks).

Tilled land: 56,118 acres.—Area planted in cotton, 12,331 acres; in corn, 24,950 acres; in oats, 3,627 acres; in wheat, 4,826 acres; in rye, 46 acres; in tobacco, 37 acres; in sweet potatoes, 421 acres.

Cotton production: 4,268 bales; average cotton product per acre, 0.35 bale, 498 pounds seed-cotton, or 166 pounds cotton lint.

There are two principal systems of drainage in Fayette county; one into the Warrior river, and the other into the Tombigbee. These are divided by a sinuous ridge having a general northern and southern direction, and known as Byler Ridge. Upon this ridge, for most of its length, is an old thoroughfare, the Byler road, much used in former times. The Warrior system may be still further divided; for a part of the water reaches the Warrior river southeastward through Lost, Cane, and Wolf creeks, while a greater part flows southward through the North river and its tributaries. The Tombigbee drainage is in general southward in three narrow belts not more than five or six miles wide east and west. The widest of these areas is that of the Sipsey, or New river; the next is drained by the Luxapolila, and the third by Hell's creek and Yellow creek, both tributaries of the Luxapolila. The ridges separating these areas are simple ridges of denudation, and the average height above the streams is about 250 or 300 feet.

The character and distribution of the soil-varieties of Fayette county depend upon the relations of the two geological formations which enter into its structure. These are the Coal Measures and the Stratified Drift. The surface formation over the whole county, except in valleys excavated by the various streams, is the latter; but beneath

it, at depths varying with the locality, may always be found the sandstones, shales, and other strata of the Coal Measures. West of the Luxapolila river no Coal Measures have been noticed, for the reason, probably, that the drainage has not cut deeply enough to expose these underlying beds. In the extreme eastern part of the county the soils depend in great measure upon the strata of the older formation, but in the rest of the county they depend upon the Drift alone.

The most important and widely spread soil is a brown loam with red clayey-loam subsoil, with timber of post, red, and black-jack oaks, chestnut, short-leaf pine, etc., such as characterizes the oak uplands in various parts of the State.

This soil is derived from red loam, which, as a rule, forms the capping over the sands and pebbles of the Stratified Drift. It grades off on the one hand into sandier, and on the other into more clayey varieties, with corresponding changes in the timber. There are two principal soil-varieties derived from the strata of the Coal Measures. These are the sandy soils of the sandstones and conglomerates, and the clayey soils of the shales of these measures. These soils, however, do not differ essentially from the sandy and loamy soils of other origin. Soils similar to those of Fayette are described in the abstracts under Winston and Marion counties.

There being as yet no railroad through Fayette county,* the cotton produced there must be hauled in wagons many miles, either to the Mobile and Ohio road, in Mississppi, or to Tuscaloosa. This lack of transportation is a serious hinderance to the production of cotton, and the small number of bales given above is due to the acreage. The soils are above the average in fertility.

Fayette county might have been classed with the oak uplands region, since the prevailing cultivated soils are those which characterize this region.

WALKER.

(See "Coal-Measures region".)

*The Georgia Pacific Road, lately constructed, passes through Fayette county.

PICKENS.

Population: 21,479.—White, 9,132; colored, 12,347.

Area: 1,000 square miles.—Woodland, all. Gravelly Pine Hills, 950 square miles; Prairie, 50 square miles).

Tilled land: 115,560 acres.—Area planted in cotton, 52,651 acres; in corn, 43,104 acres; in oats, 8,053 acres; in wheat, 2,220 acres; in rye, 36 acres; in tobacco, 51 acres; in sugar-cane, 19 acres; in sweet potatoes, 757 acres.

Cotton production: 17,283 bales; average cotton product per acre, 0.33 bale, 471 pounds seed-cotton, or 157 pounds cotton lint.

The soils, topography, and other natural features of Pickens county are dependent almost entirely upon a single formation, the Stratified Drift, which makes the surface over all, except the extreme southwestern corner of the county, where the calcareous beds of the Cretaceous formation are exposed. All the drainage is into the Tombigbee river by Sipsey river and Bear, Lubbub, and Coal-fire creeks. The face of the country throughout the county is quite broken, as is always the case where the Drift is the prevailing formation. This is well illustrated between Tuscaloosa and Carrollton, where the road passes over a succession of little hills, separating the drainage areas of the creeks. The prevailing timber here is a mixture of the upland oaks with short-leaf pine. With the loam soils, which prevail, there is in places a large proportion of clay coming from the drift beds, and where this material is abundant the soil is quite stiff and the post oak forms the principal tree. South of Carrollton the lowlands of Lubbub creek, one or two miles in width, form excellent farming land. The divide between this and Blubber creek is a fine table-land with brown-loam soil, timbered with the upland oaks, and very fertile.

Southwest of a line joining Pleasant Ridge, in Greene county, with Pickensville, the Cretaceous strata form the country, but do not in any great dgree influence the soils on the northeastern side of the river; but beyond it the prairie soils of the usual character make their appearance, forming the great proportion of the lands in the southwestern corner of the county. Drinking water in this region is ob-

tained from bored or artesian wells, as the surface water at certain seasons is both scanty in quantity and of poor quality.

The upland soils of Pickens vary from the best brown to sandy loams, and all rest upon red-clay loam, which itself is generally underlaid with sand and pebbles. The bottom and hummock lands in the greater part of the county have in general the characters of the loam uplands which adjoin them, and are in many cases of superior quality. Southwest of the river the topography is less varied than elsewhere, the country being gently undulating, with low ridges of drift to relieve the monotony. The soils in this part of the county are the usual Rotten-Limestone prairie soils and the varieties resulting from the intermixture of this with the surface loams of the Drift.

In its agricultural features Pickens county resembles its neighbors, and presents no special peculiarities.

ABSTRACT OF THE REPORTS OF M. F. COOK, OF PICKENSVILLE, AND R. F. HENRY, OF COLUMBUS, MISSISSIPPI.

(These reports relate to the bottom and uplands of Coal-fire creek and to those of McBee creek, both streams tributary to the Tombigbee river.

Late springs, with cold rains, sometimes cause poor stands of cotton, and late frosts kill the young plants. In the northern part of the county the uplands are generally poor from long and careless cultivation; yet the few level spots are still quite productive. The bottom lands generally produce good crops of cotton, except in a few cases where the soil is gravelly. When planted in time and properly cultivated the whole crop will generally open before killing frosts. On the uplands of the central and southern parts of the county cotton rarely fails, especially if fertilizers are applied before planting. The western part of the county is a good cotton country, and entire failures of the crop are unknown.

The most widely-spread soil in the county is the brown loam of the uplands, which varies from a rather heavy and fertile to a light sandy loam. The subsoil in most cases is a stiff, reddish clayey loam, sometimes yellow, with sand and gravel underlying at varying depths. Now and then there are patches of crawfishy soil, with whitish clay beneath. The timber of the uplands consists of pine, red, black, Spanish, and black-jack oaks, hickory, chestnut, etc., with white, water, and willow oaks, ash, cypress, beech, sweet and sour gums, and others in the lowlands.

The lowlands and bottom lands have generally a "made soil", which is a light loam, more or less sandy, of dark, sometimes black, colors. These also have usually a red-clay subsoil, much like the subsoil of the adjacent uplands. The soils of the bottoms are often of considerable thickness; that of the uplands varies greatly, being in places almost entirely washed off.

From one-half to three-fourths of the county has a sandy soil, especially on the water-sheds, and this soil has a natural growth of pine, mixed with the several species of oaks, and with hickory where of better quality. These soils are of gray to dark colors, and sometimes a foot or more in thickness. The subsoils are also sandy, holding pebbles.

These lands are generally easy to cultivate. The chief crops are cotton, corn, oats, and potatoes, but the soil is best adapted to cotton, potatoes, and oats. More than one-half of the cultivated land is in cotton. The height to which cotton grows varies from two to six feet. The seed-cotton product per acre on fresh land is about 1,000 pounds, and it requires 1,545 pounds to make a 475 pound bale; but the staple is not as good as that from old, fertilized land. After two or three years' culture the yield is increased, but after five years the uplands begin to wash, and there is a falling off in the yield; but the bottom lands are as productive now as 20 years ago. Morning-glory, crab-grass, and purslane are especially troublesome. Only a small part of the uplands is turned out. Such turned-out lands will produce well if Japan clover cover them one or two years. The hillsides and slopes are somewhat injured by washings, but this may be, and is prevented, by ditching, underdraining, etc.

TUSCALOOSA.

(See "Gravelly Pine-hills region").

GRAVELLY HILLS, WITH LONG-LEAF PINE.

This region includes parts of Pickens,* Tuscaloosa,* Greene,* Hale,* Bibb, Perry,* Chilton, Autauga, Elmore, Montgomery,* Tallapoosa,* Macon,* Lee,* and Russell.*

PICKENS.

(See "Oak and Hickory Uplands, with Short-leaf Pine.")

TUSCALOOSA.

Population: 24,957.—White, 15,216; colored, 9,741.

Area: 1,390 square miles.—Woodland, all. Four hundred square miles are Gravelly Pine Hills (250 square miles with short-leaf pine and 150 with long-leaf pine), and, in addition to this, of the 965 square miles of the Coal Measures 675 square miles have the characters of the Gravelly Pine Hills, 225 square miles with short-leaf and 450 square miles with long-leaf pine; 25 square miles in Roup's Valley.

Tilled land: 111,171 acres.—Area planted in cotton, 33,773

acres; in corn, 38,638 acres; in oats, 6,974 acres; in wheat, 2,689 acres; in rye, 130 acres; in sugar-cane, 35 acres; in tobacco, 20 acres; in sweet potatoes, 919 acres.

Cotton production: 11,137 bales; average cotton product per acre, 0.33 bale, 471 pounds seed-cotton, or 157 pounds cotton lint.

A line drawn from the northwestern to the southeastern corner of Tuscaloosa county, through or near the city of Tuscaloosa, will divide the county into two parts of unequal size, differing widely in soils, topography, and other natural features. North and east of this line the county is formed of the sandstones and shales of the Coal Measures; south and west, of the sands and loams of the Stratified Drift formation. These last-named materials, however, overlie the rocks of the Coal Measures in a belt twelve or fifteen miles wide, lying northeast of the line alluded to. Southwest of this line the Drift hides completely from view any underlying rocks, but northeast the Coal Measures are everywhere brought to light where the former has been removed by erosion. In the southeastern edge of the county, adjoining Bibb, there is a narrow belt, in Roup's Valley, where the rocks of a still lower geological formation take part in the formation of the soils and in the production of scenery.

The Black Warrior river, which flows in general southwest through the center of the county, receives nearly all the drainage, and the Sipsey river, a tributary of the Tombigbee, drains the northwestern corner. This river is separated from North river, the principal tributary of the Warrior, by a ridge of sand and pebbles of the Stratified Drift, known as Byler Ridge, upon which was one of the principal thoroughfares of the county before the days of railroads.

In all that part of the county where the rocks of the Coal Measures are at the surface the soils are mostly sandy, occasionally shaly or aluminous, and seldom very fertile. The uplands are timbered with the usual variety of oaks, hickory, and pine, and bring tolerably fair crops. In this part of the county the bottom lands of the river and creeks are most esteemed by farmers. From the northeastern

corner down nearly to the city of Tuscaloosa the river bottoms are rather narrow, except in the great bends, and in some parts of its course, as at the Squaw Shoals, the river flows between high, rocky banks, with almost no bottom lands on either side. The adjacent uplands, also formed by the same rocks, are very rugged, difficult to cultivate, and rather poor. A large area in the northeastern part of the county is thinly settled, but the woods are well stocked with deer and other game, which find excellent pasture in the grasses and leguminous plants which there abound. Below Tuscaloosa the first and second bottoms (partly above overflow) to the lower limit of the county will average one mile in width, and have a reddish loamy soil and red subsoil, derived from the uplands, and form the best farming area of the county. In all the southwestern part of the county, where the Stratified Drift is at the surface, the topography shows the usual variety characteristic of this formation.

From the lowlands along the river there is usually a rather abrupt rise of from sixty to seventy-five feet to a terrace or plain, which is often five or six miles wide. Upon this stands the beautiful city of Tuscaloosa. From this plain the ground rises from the river, sometimes gradually, sometimes abruptly, to the general level of the uplands, which, upon the main water-sheds, is not less than 250 or 300 feet above the water-courses. This elevation is not reached in the lower part of the county usually within ten miles of the river. Throughout this part of the county the prevailing soils are brown loams of considerable fertility, overlying subsoils of red clayey loam, which in turn rest upon beds of gravel and sand. The bottom lands are more or less closely related to the uplands from which they are derived, but are usually rather more fertile, containing, as they do, the cream of the upland soils.

At some distance from the river, upon the water-sheds spoken of above, the soils are somewhat more sandy. The long-leaf pine grows upon the sandy soils in all the southwestern part of Tuscaloosa county, and also east and northeast of the city of Tuscaloosa for a distance of twenty-five or thirty miles, or nearly to the county limits. In these

localities the rocks of the Coal Measures are covered with beds of pebbles and sand of the Drift. The genuine piny woods are here, as elsewhere, rather poor and thinly settled, but, with a moderate outlay for manures, they yield very fair crops of cotton.

The greater part of the cotton crop of Tuscaloosa county is raised upon the soils derived from the Drift and Loam, and comparatively little upon those of the Coal Measures.

Analyses presented above in giving the general characters of the Southern Division, and in connection with the agricultural description of the Gravelly Pine Hills, will show the composition of the principal soil varieties of Tuscaloosa, as well as of the other counties adjoining.

ABSTRACT OF THE REPORTS OF HON. A. C. HARGROVE AND JAMES R. MAXWELL, OF TUSCALOOSA.

(Both reports refer to the bottom lands of the Warrior river and the adjacent uplands.)

The growth of the cotton-plant depends, to a great extent, upon the temperature and humidity. In the bottom lands it is likely to be late, and, therefore, more exposed to frosts and the ravages of the caterpillar; and for these reasons, the uplands are preferred for cotton where the soils are at all fair. On the uplands, the cotton grows off well about the last of April, and matures about the third week in September. The picking sometimes begins the last week in August. On manured or fresh land, it continues to make till frost; the most of it, however, is made by the middle of September.

The bottom lands of the Warrior river and tributary creeks are of two principal kinds, the stiff, yellowish soil and the loose gray. The two together make up the soils of the bottoms from Tuscaloosa to the southern limit of the county, with a width of one mile and a length of twenty-five or thirty miles. The natural growth consists of beech, white and red oaks, sweet gum, poplar, elm and cottonwood, with occasional dense thickets of cane. The stiff soil is a heavy clayey loam of a gray to yellow color, sometimes inclined to be black, especially when wet. The thickness varies from eight to twelve inches. The subsoil is sometimes heavier, sometimes lighter, than the surface soil, and is of a yellowish or buff color when dry. When the surface soil is washed away, this subsoil appears to be almost barren, though shown by chemical analysis to be rich in potash and phosphoric acid. The barrenness is due to the physical condition. When dry, the subsoil becomes very hard, but absorbs water rapidly, and then becomes a sticky clay. It contains now and then soft, black gravel, and the whole is underlaid at varying depths by beds of sand and gravel. The stiff, yellow soils are difficult to cultivate, except in the proper seasons, for they are too sticky in wet, and too hard in very dry weather. The loose, gray bottom

soils are always easily tilled. The stiff soils are inclined to be late, cold and ill-drained, while the loose gray soils, on the contrary, are early and warm.

The soil next in importance is the brown loam of the uplands. This makes from one-half to two-thirds of the uplands, the rest being sandy, piny woods. The timber consists of post, red and Spanish oaks, black-jack, hickory, poplar and short-leaf pine. The soil is in general a brown loam from three to ten inches in thickness, with a heavier subsoil of reddish clay, which is often almost impervious. The subsoil rests upon beds of sand and gravel, occasionally mixed with clay, and often contains pebbles. These upland soils are early and warm when well drained, which is the case with most of them.

The long-leaf pine woods make up a considerable proportion of the highest uplands. The natural growth is the long-leaf pine, with black-jack and other species of oaks where the soil is more fertile. The soil is a light-colored, sandy loam, two or three inches in thickness, resting upon a sandy subsoil, which often contains rounded pebbles of quartz. These sand and gravel beds underlie also the subsoil to considerable depths. The soils are always easily tilled.

The chief crops are cotton, corn and oats, but many other crops grow well. The soil generally is perhaps best adapted to cotton, but bottom lands produce fine crops of corn. Fully one-half of the tillable lands are devoted to cotton culture. On bottom lands, cotton grows from five to eight feet high; on uplands, from three to four feet, the latter being generally most productive. About one-fourth of the land originally tilled is now turned out, which produces well for two or three years, and then rapidly deteriorates. The slopes are much injured by washings; on the other hand, the valleys are often improved by the washings of the top soil from the uplands. The damage to slopes is prevented or checked by hillside ditching.

GREENE.

(See "Central Prairie region.")

HALE.

(See "Central Prairie region.")

BIBB.

Population: 9,487.—White, 5,887; colored, 3,600.

Area: 610 square miles.—Woodland, all. Hilly lands, with long-leaf pine, 310 square miles; 125 square miles in Cahaba Coal-field; 100 square miles in Roup's Valley; 75 square miles Valley lands south of the Cahaba Coal-field. About 120 square miles of the southern parts of the Coal-field and the valleys are covered with the Drift, and exhibit the characters of the Gravelly Hills, with Long-leaf Pine.

Tilled land: 43,796 acres.—Area planted in cotton, 15,737 acres; in corn, 18,816 acres; in oats, 2,935 acres; in wheat, 3,125 acres; in rye, 151 acres; in tobacco, 36 acres; in sugar-cane, 36 acres; in sweet potatoes, 368 acres.

Cotton production: 4,843 bales; average cotton product per acre, 0.31 bale, 441 pounds seed-cotton, or 147 pounds cotton lint.

The northwestern corner of Bibb county is occupied by the narrow trough of Roup's Valley, which is well defined as far south as the base line between the two surveys (which runs east and west about twelve miles north of Centreville). Below this, the sands, loams, and pebbles of the Drift hide all the underlying formations. The characters of Roup's Valley, with its parallel ridges and subordinated valleys, have been given under Jefferson county.

In Bibb county, the ridge which occupies the central part of the valley is quite conspicuous, and is in many places filled with iron ore of good quality, and embraces many acres of fine farming land where not too much broken. The color of the subsoil is usually a deep-red; the soil is more sandy, and of a brown color. Between this and the red-ore ridges, which are found near the margins of the valley, but not always prominent landmarks, are belts of valley land, with gray and yellowish to red soils and red subsoils, mostly under cultivation. The quality of these soils varies with the locality. As a rule, they contain angular fragments of chert, derived from the flinty limestones upon which they are mostly based. Of considerable extent also is a gray, gravelly soil, with light-colored subsoil, filled with fragments of lint. Between the red-ore ridges and the extreme margin of the valley on each side, there are narrow depressions, with a first-rate yellowish calcareous soil.

East of Roup's Valley, and occupying the northeastern part of the county, are the Coal Measures of the Cahaba field. The southwestern limit of this field is near Scottsville. It is drained by the Cahaba river, and forms a very rugged and broken area, with prevailing sandy soils of no great fertility. Near the confluence of Shade's creek with this river is a region known by the expressive name of "The Uglies," almost uninhabited, and embracing some of the

most broken land in the county. As a rule, the area formed by these Coal Measures is not densely populated, as the soil is not productive enough to offer any inducements to the settler.

Between the southern edge of the coal-field and a line running from Centerville northeast to the county line there is an area of valley land with flinty ridges and the other characteristics of the valley lands of Central Alabama. In this area there are many tracts of fine farming land, with red, buff, and gray soils, derived from the cherty or flinty magnesian limestones of the country, and giving evidence of their origin in the great number of angular fragments of chert with which they are filled. The red lands are more fertile and better suited to the grain crops, while the gray lands, sandy and timbered with pines, are preferred for cotton.*

South of Pratt's ferry a mountain rim, composed of the chert of the sub-Carboniferous formation, incloses a basin of two or three square miles area with yellowish soil, differing from the usual red valley soils and derived from an entirely different series of rocks. This has its representative in the Dry Valley soil of Cherokee county, an analysis of which has been presented on page 210.

The southern part of the county, embracing the lower 12 miles, depends for its topography and surface features essentially upon a single formation, the Stratified Drift. This formation consists of beds of sand, pebbles, and loam of great thickness, which overlie and hide from view the older rocks. The cultivated soils are mostly derived from a bed of red loam, which is usually the uppermost of the whole series, and which is nearly always prominent in the subsoils. In this part of the county the ridges and depressions are determined solely by the water-courses, and do not lie in parallel, sharply-defined belts, which are so characteristic of the upper part. The high lands separating the main streams have a brown-loam soil resting upon this red loam as subsoil. Its timber is a mixture of the various spe-

*An analysis of a red upland soil from near Pratt's Ferry, has been given in the preceding section in connection with the agricultural description of the Coosa Valley Region.

cies of upland oaks, and as the top soil becomes more sandy the long-leaf pine associates itself with these, and the transition into the long-leaf pine woods takes place by gradual stages. Wherever the soil is very sandy or pebbly, and the subsoil light, the long-leaf pine is the prevailing growth.

Agriculturally, Bibb county shares the characteristics of the valley region and those of the pine hills and brown-loam uplands, the greater part of the cotton crop being raised upon the brown-loam soils. The subjoined report does not refer to any of the brown-loam or sandy soils, and for descriptions reference must be made to the descriptions under Perry, Hale, and Tuscaloosa counties, where entirely similar soils prevail.

ABSTRACT OF THE REPORT OF J. S. HANSBERGER, OF TIONUS.

(This report refers to the region of Six-Mile Creek, a tributary of the Cahaba river.)

The two-principal soil-varieties described are the red-clay loam lands and the gray sandy lands, which make about equal proportions of the region under consideration. The timber is composed of oak, hickory, walnut, and poplar on the red lands, and chiefly long-leaf pine on the other. The top soil of the red lands is a clay loam of a red to brown color, from two to ten inches in thickness, resting upon a subsoil which is of heavier quality and of deeper red color. This subsoil often becomes hard and almost impervious. The top soil of the gray lands is of lighter color and more or less sandy, and its subsoil is of a yellowish color, somewhat sandy also, and seldom becoming hard and "panny."

The cultivation of the land is easy in dry weather, but somewhat difficult in wet seasons. The chief crops are cotton, corn, wheat, oats, rye, barley, and sweet potatoes. The red lands are adapted to corn, cotton, and wheat; the gray lands to cotton and potatoes. About one-third of the land is planted in cotton, which grows to the average height of three feet. About one-third of the land originally cultivated is now turned out, and some portions of this land, when taken into cultivation again, produce well, but other portions are worthless. The washings of the slopes is being checked to a considerable extent by hillside ditching.

PERRY.

(See "Central Prairie region.")

CHILTON.

Population: 10,793.—White, 8,651; colored, 2,142.

Area: 700 square miles.—Woodland, all. Four hundred square miles of Gravelly Hills with Long-leaf Pine; 220 square miles Metamorphic slate region; 80 square miles

Valley lands, Silurian, etc. (Part of the last two divisions are also covered with Drift and partake of the characters of the Gravelly Pine-Hills.)

Tilled land: 40,676 acres.—Area planted in cotton, 11,558 acres; in corn, 18,185 acres; in oats, 2,255 acres; in wheat, 4,507 acres; in rye, 60 acres; in sweet potatoes, 356 acres.

Cotton production: 3,534 bales; average cotton product per acre, 0.31 bale, 441 pounds seed cotton, or 147 pounds cotton lint.

The eastern part of Chilton county is formed by the crystalline rocks, the western part by the strata of the Drift formation, and at the line of separation of the two, which is approximately along the line of the North and South Alabama railroad, there is a high ridge of the Drift which forms the water-shed between the Coosa and the Alabama rivers. In many places this water-shed is 300 feet above the immediately adjacent streams. The course of the Coosa river, which forms the eastern boundary of Chilton, is nearly parallel with this ridge.

In addition to the above-named formations, there appear in the upper part of the county certain Silurian strata, which, however, are, as a rule, more or less covered with the beds of Drift, and therefore not solely concerned in the formation of the soils. Near Verbena, in the belt of crystalline rocks, there is an occurrence of hornblendic rocks which yield red and brown soils, and south of these are chiefly mica slates, yielding sandy gray soils, with much long-leaf pine associated with the oak growth. Northward from Verbena the gray soils prevail, and the long-leaf pine is nearly always present among the trees. Immediately north of the belt of red-colored soils mentioned as occurring near Verbena there is an area formed by a much-decayed mica slate of purplish tinge which yields an extremely sterile soil, upon which the chief growth is stunted long-leaf pines and black-jack oaks. In this region the surface is much broken. These slates are traversed by veins holding large masses of mica, which may some day be profitably worked. Northward from this the rocks are mostly siliceous and clay slates, with gray soils; long-leaf pine timber prevails, and the surface in places is exceedingly broken. The highest

land in the county is probably to be found in this region. Of the specific characters of the red and gray soils here occurring little need be said, since similar soils have been mentioned under all the counties in which the crystalline rocks are more wi dely distributed.

The western part of the county formed of the strata of the Drift presents the usual variety which characterizes that formation everywhere. These soils vary from the rich red and brown loams of the oak and hickory uplands to the gray sandy soils of the pine woods.

The water-shed mentioned as lying on the eastern border of the Drift area is in general a high table-land with gray sandy soil and a splendid growth of long-leaf pine timber, supplying some of the largest saw-mills in the State, located along the line of the North and South Alabama railroad. This pine region extends southward into Autauga and Elmore counties, and analyses of several typical soils of these pine forests in the former county have been given on page 247.

Westward in the drainage area of Mulberry creek and of the other small streams of the county brown-loam soils of very good character are found and are in cultivation. This part of the county also is much more densely populated and is of much more importance, agriculturally, than the eastern, where the pine timber and the mineral resources are the chief interests.

The agricultural capabilities of Chilton county are quite similar to those of Autauga on the one hand, and of Coosa on the other.

Cotton is hauled to the stations on the North and South Alabama and Selma, Rome, and Dalton railroads, and there sold to merchants, who ship it thence to the various markets.

AUTAUGA.

Population: 13,108.—White, 4,397; colored, 8,711.

Area: 660 square miles.—Woodland, all. Gravelly Hills, with Long-leaf Pine, 560 square miles; Calcareous lands, 100 square miles.

Tilled land: 81,388 acres.—Area planted in cotton, 30,474

acres; in corn, 20,417 acres; in oats, 2,153 acres; in wheat, 700 acres; in rye, 63 acres; in rice, 43 acres; in sugar-cane, 22 acres; in sweet potatoes, 540 acres.

Cotton production: 7,944 bales; average cotton product per acre, 0.26 bale, 372 pounds seed-cotton, or 124 pounds cotton lint.

Autauga county is one of the counties situated upon the great pebble bed which covers and hides from view the line of contact of the older crystalline or metamorphic rocks and the newer Cretaceous, and, as might be expected from this circumstance, its upland soils are almost exclusively derived from these drifted materials.

The northern two-thirds of the county, viz: townships 18, 19, and all of 20 which lies within the county, are piny-woods land, hilly and timbered with long-leaf pine, and often with no other tree except the black-jack oak. In many places, especially north of Kingston, even undergrowth of shrubs is wanting, but grasses and leguminous plants flourish and afford excellent pasturage. The soil is coarse to fine-sandy and often gravelly, and the red or yellow loam is almost entirely wanting, except in the subsoil, often at considerable depth from the surface. In these lands only the hollows and creek flats are worth cultivating, and perhaps not more than one acre in thirty is, or ever has been, cleared up and in cultivation.

Coming southward, there is, as a rule, an improvement in the land, and pine land with red clay or clayey loam subsoil makes up a good part of townships 17 and 18. Some of these soils have a sandy subsoil; that is, the loam lies deeper below the surface. Nearly all the pine lands with clay subsoil have been cleared up, not because they are better in the virgin state than the soils with sandy subsoil, but because they lie better, are more level, and consequently last longer. As to productiveness they are about equal, the fresh land yielding about 400 pounds of seed-cotton to the acre. About one-fifth of township 17 is table-land, level, and having an average elevation above the water-courses of 225 or 250 feet. The rest of the township is made up of the steep hillsides which border these table-lands and the creek hummocks, which are very much like the river hummocks.

From the piny woods of the upper townships two strips of pine land run down into this township (17): the one, on the borders of Autauga creek, to the river; the other, on White-water creek, to within two miles of the river.

The table-lands have a natural growth consisting of short-leaf pine, red, Spanish, black, and post oaks, hickory, dog-wood, black gum, etc. These have a clay foundation, and will yield, when fresh, from 1,050 to 1,200 pounds of seed-cotton to the acre. The same is true of the hillsides, which are good farming lands when level enough to plow and can be protected from washings.

There are two outcroppings of the calcareous rocks of the Cretaceous formation in the county, viz: one, about five miles long, lying between Nolan's and Bear creeks, in township 17, on the plantation of General Fair; the other near the river below the Dutch Bend. Taken together, the area of these Cretaceous or prairie tracts is small, only about ten sections. All of this kind of land that is level enough to plow has been cleared up, and it is equal to, or perhaps better, than any land in the county, yielding, when fresh, from 1,200 to 1,500 pounds of seed-cotton to the acre.

Nearly all of township 16 in this county is second-bottom or river-hummock land, and most of it is in cultivation. In this township also are the first bottoms of the Alabama river, which are very rich and productive; but being liable to overflow in the spring, are devoted almost entirely to corn, the yield of which is from forty to fifty bushels to the acre. An analysis of a specimen of river-bottom soil from this county has been given on page 249. The hummocks and the table-lands are about equally productive, giving, as above stated, from 1,000 to 1,200 pounds of seed-cotton.

For many of the above-named facts I am indebted to Dr. S. P. Smith, of Prattville.

The southern boundary of Autauga county is made by the Alabama river, and the sandy loams of the second-bottoms of this river and of the streams that flow into it have produced the great proportion of the cotton crop. The calcareous lands in the southwestern part of the county, while of limited extent, are very superior cotton lands. The red or brown-loam table-lands also furnish fine plantations, but

much of this land is badly worn, although with proper care, susceptible of almost unlimited improvement.

ABSTRACT OF THE REPORT OF DR. C. M. HOWARD, OF MULBERRY.

(The region reported upon is in township 17, range 13, in the drainage areas of Beaver and Ivy creeks, and embraces the bottom lands of those streams, and also the hilly and table-lands of the same drainage area.)

The soils vary from tolerably stiff to light sandy clay loams, and include also the creek bottoms. The most important are the red land (loam soil), occupying about one-half to three-fourths of the region described. The timber consists of post, white, and red oaks, hickory, short-leaf pine, chestnut, dogwood, and sassafras. The thickness of the red soil is from one to four inches, the subsoil generally heavier, a close clay, often plastic, and containing occasionally pebbles. Beneath the subsoil are either sand, pebbles, or clay at varying depths. Alternating with the loam soils above named, and forming perhaps a fourth of the area under discussion, are the sandy lands with timber of long-leaf pine and black-jack oaks, and occasionally other species of oak. This is a much lighter soil, more sandy, and of gray to brown colors and from one to three inches in thickness, having a close yellow clay, more or less mixed with sand as subsoil. This subsoil also often holds, locally, beds of pebbles, and rests on sand and gravel, and in places on lime-rock, at varying depths. The bottom soils make from one-third to one-fifth of the area, and have a growth of oaks, poplar, beech, gum, iron-wood, etc. The soils are light, fine loams, often heavy, of gray brown to blackish colors, and from three to eight inches in thickness. The subsoil, as a rule, is lighter than the surface soil, often containing pebbles, and is underlaid with sand and gravel.

Land is easily tilled in wet and dry seasons. The chief crops are cotton, corn, oats, and potatoes, the soil being well suited to all. Two-thirds of the tilled land is planted in cotton, which grows from two to five feet high—the higher the better for production. After twenty years' rest for turned out land it will produce an average crop for two or three years. The soil on slopes is often much damaged by washings, and no efforts have been made to prevent the injury.

ELMORE.

Population: 17,502.—White, 8,747; colored, 8,755.

Area: 630 square miles.—Woodland, all. Gravelly Hills with Long-leaf Pine, 230 square miles; Crystalline or Metamorphic area, 400 square miles. Of the last named area 175 square miles are also covered with Drift, making in all 405 square miles in which the Drift soils prevail.

Tilled land: 73,897 acres.—Area planted in cotton, 31,045 acres; in corn, 20,000 acres; in oats, 5,153 acres; in wheat, 3,883 acres; in rye, 27 acres; in rice, 5 acres; in tobacco, 12

acres; in sugar-cane, 16 acres; in sweet potatoes, 642 acres.

Cotton production: 9,771 bales; average cotton product per acre, 0.31 bale, 441 pounds seed-cotton, or 147 pounds cotton lint.

Elmore county, like Lee, embraces the line of junction of the older crystalline rocks and the Cretaceous, but this line of contact is, as usual, hidden by the great accumulation of pebbles and sand of the Post-Tertiary. None of the Cretaceous beds, so far as yet known, come to the surface, and the soils are made exclusively of the disintegrated metamorphic rocks or the overlying Drift loams. The crystalline rocks form the county north of the latitude of Wetumpka, and in this area are the usual red and gray soils elsewhere described as derived from the gneisses which constitute the greater part of the strata.

The gray lands predominate greatly in Elmore county, and are derived either from gneisses or from mica slates. Their fertility varies on this account between wide limits, as the mica slates, as a rule, yield soils of no great value, while some of the gneissic soils are of excellent quality. From eight or ten miles north of Wetumpka, southward, the Stratified Drift covers the country rocks everywhere, except where the drainage has cut through to the underlying beds.

The Coosa river above Wetumpka has rather narrow bottom lands, but beyond the bottoms, and of two or three miles width, is a tolerably level plain with sandy soil (occasionally mingled with pebbles), and timbered with long-leaf pine. West of the river, in the latitude of Wetumpka, the country is an almost perfectly level plain to the Autauga county line, with an occasional slight elevation caused by an accumulation of pebbles. Upon this plain the soil is sandy and the subsoil rather stiff, so that the roads are always firm and hard, notwithstanding the sands. The timber is one unbroken forest of long-leaf pines, with very little shrubby undergrowth, but with a great variety of herbaceous plants, with showy flowers, especially in the moist depressions. Along the Tallapoosa, and in the fork of the Coosa and Tallapoosa rivers, there are tracts of first-class bottom lands, which have for many years yielded heavy crops of cotton.

The higher bottom lands above overflow, and the second

bottoms of the two rivers that form the southern and western boundaries of Elmore, are perhaps the best cotton lands in the county, but some of the brown-loam table-lands and of the better quality of gneissic soils, yield excellent crops. Shipments are made either by rail or by boat on the Coosa.

MONTGOMERY.

(See "Central Prairie region.")

TALLAPOOSA.

(See "Metamorphic region.")

MACON.

(See "Central Prairie region.")

LEE.

(See "Metamorphic region.")

RUSSELL.

(See "Central Prairie region.")

THE CENTRAL PRAIRIE REGION.

This division comprises the whole or part of the following counties: Pickens,* Sumter, Greene, Hale, Marengo, Perry, Dallas, Wilcox,* Butler,* Lowndes, Autauga,* Montgomery, Crenshaw,* Pike,* Bullock, Macon, Russell, and Barbour.

PICKENS.

(See "Gravelly Pine Hills region.")

SUMTER.

Population: 28,728.—White, 6,451; colored, 22,277.

Area: 1,000 square miles.—Woodland; all, except a few isolated patches of open prairie, the extent of which cannot be given with accuracy, but is about 35 to 40 square miles; Central Prairie region, 575 square miles; Post-oak

Flatwoods, 175 square miles; oak and Hickory Uplands with Long-leaf Pine, 250 square miles.

Tilled land: 172,100 acres.—Area planted in cotton, 80,662 acres; in corn, 51,402 acres; in oats, 2,706 acres; in wheat, 24 acres; in rye, 162 acres; in sugar-cane, 42 acres; in tobacco, 13 acres; in sweet potatoes, 1,056 acres.

Cotton production: 22,211 bales; average cotton product per acre, 0.28 bale, 399 pounds seed-cotton, or 133 pounds cotton lint.

A line running northwest and southeast through Livingston would mark approximately the limit of the prairies which form the upper part of Sumter county down to that line. This part of the county has an average elevation of about 150 feet above tide, and is underlaid throughout with the Rotten Limestone of the Cretaceous formation. This material is directly concerned in the formation of a considerable proportion of the soils, which are in some cases little more than the disintegrated limestone mixed with organic matter. Where this rock forms the surface the country is gently undulating, and the differences in level are very slight. Interspersed, however, throughout this whole canebrake region are ridges and hills capped with sand and pebbles of the Stratified Drift formation. These ridges are occasionally elevated 150 feet and more above the surrounding country and 250 feet above the river. Their distribution, stucture, and other circumstances point to the conclusion that they are the remnants of a once universal covering of Drift. Where this formation is at the surface the soils are sandy loams of the usual Drift type. These loams, in mingling with the disintegrated limestone, give rise to a class of soils known as post-oak or prairie soils. As will be seen in the abstract of Dr. Webb's report, there are all gradations between the sandy loams and the black-prairie soils. The open or bald prairie spots form only a small percentage of the whole area formed by the Cretaceous limestone (less than one-tenth.)

Southwest of the line above alluded to, and occupying a belt varying in width from five to eight miles, are the so-called Flatwoods or Post-oak Flatwoods. This division shares with the prairies their gently undulating surface and

elevation above tide. It rests, however, upon a bluish, tenacious clay of the lowest Tertiary formation. Like the prairies, this belt is covered in spots with the sands and other material of the Drift, and the varieties of soils thus produced by intermixture are quite numerous. Beyond the Flatwoods, in the southwestern part of the county, the sandy and clayey strata of the lignitic group of the Tertiary are, as a rule, hidden from view by the overlying beds of sand and pebbles and red loam of a later formation. This portion of the county presents the usual characters of the Drift regions so often previously described. The high, level table-lands which occupy the main water-sheds have a sandy-loam soil and red-loam subsoil resting upon sand and pebbles, and these in turn overlie the laminated clays and other beds of the lignitic group. Sometimes the surface is made up of deep beds of sand, as is the case near Gaston. The growth upon these sandy tracts consists mostly of long-leaf pine and black-jack oak. Beds of lignite are exposed in many places throughout this section, and one of these, in a cut along the Alabama Great Southern railroad, has been on fire for many years. As yet this lignite has not been profitably used as a fuel.

The agricultural relations of Sumter county are similar to the adjoining counties of Mississipi and Alabama, which are situated in the same belt, which is pre-eminently the cotton belt of the State. While the soils of this belt are, perhaps, in the elements of plant-food not much superior to those of other divisions, they are rendered more thrifty by the usually notably large percentage of lime.

ABSTRACT OF THE REPORT OF DR. R. D. WEBB, OF LIVINGSTON.

(*This report refers to the bottom lands of Sucarnatchee river, a tributary of the Tombigbee, and to the prairies and uplands drained by the same.*)

The three soils described are: the prairies or black lands, the upland and alluvial (creek bottom) sandy soils, and lastly, the post-oak flatwoods.

The basis of the first is the Cretaceous limestone, that of the last a dense, firm, blackish-blue clay, and that of the sandy uplands the Drift or Orange Sand overlying the two former. The region about Livingston is a spotted one, having, in addition to the three primary soils above mentioned, quite a variety of mixed soils, such as sandy flatwoods, prairie flatwoods, sandy prairie, prairie loam, etc. There is very little bottom land on the Tombigbee in this section.

The black prairie soil forms two-thirds of the lands in township 19, ranges 1, 2, 3, and 4 west, and extends northwestward to Mississippi, and in the other direction, through Marengo, Greene, Hale, Perry, Dallas, and Montgomery, to Macon county. The timber is a mixture of post, red, and white oaks, hickory, ash, walnut, and cedar. The soil is black, putty-like prairie, with no subsoil, properly speaking, as the soil rests directly upon the underlying limestone, from which it has been derived. Its thickness is quite variable (from three to five feet, sometimes ten to twelve.) This soil is easily tilled when dry, but difficult when wet.

The sandy uplands make up one-sixth of the region in question, and are widely distributed. The prevailing timber is chestnut, black-jack, red, and white oaks, hickory, black and sweet gums, long-leaf pines, and occasionally poplar. The soil is a sandy loam of brown to yellowish colors, with an average thickness of one foot to the subsoil, which is a red-clay loam, containing occasionally rounded pebbles of quartz.

The post-oak flatwoods form one-sixth of the region described, and extend northwestward to Mississippi and southeastward nearly to the Alabama river, in upper Wilcox county. The natural growth is post oak, pine, and hickory. The soil is usually a putty-like clay of a brown color, often 10 to 15 feet thick and without a distinct subsoil, and is underlaid below the depth of 10 or 15 feet with a stiff black clay impervious to water. From its nature this soil is difficult of cultivation, late, cold, and badly drained.

Of these soils the prairies are about equally well adapted to corn and cotton, the open prairies, perhaps, being best for corn. The other two soils are best suited to cotton, and this is almost the only crop on the flatwoods. On the prairies the stalk attains the height of three to seven feet, being most productive at five feet. On the other soils the best height is about three feet. One-third of the uplands formerly in cultivation now lie turned out. Of the other lands, very little has been abandoned, and of the flatwoods, more is in cultivation now than ever before. In all cases where again taken into cultivation the land produces well. In the prairies and uplands there is some injury from washings, and the valleys suffer to a slight extent; in the flatwoods, on account of their level nature, there is no injury from this cause. Hillside ditching has been practiced to a limited degree, and with good success where properly done.

GREENE.

Population: 21,931.—White, 3,765; colored, 18,166.

Area: 520 square miles.—Woodland, all, except a few small patches of open prairie, aggregating perhaps 25 square miles; prairie region, 395 square miles; Gravelly Hills, with Long-leaf Pine, 125 square miles.

Tilled land: 119,426 acres.—Area planted in cotton, 63,643 acres; in corn, 31,826 acres; in oats, 2,163 acres; in wheat, 214 acres; in rye, 25 acres; in sugar-cane, 25 acres; in tobacco, 41 acres; in sweet potatoes, 705 acres.

Cotton production: 15,811 bales; average cotton product

per acre, 0.25 bale, 357 pounds seed-cotton, or 119 pounds cotton lint.

Greene county occupies a position with reference to the geological formations similar to that of Perry and Hale. In the northern part is the belt of Drift, of which mention has frequently been made, and in the southern, the prairie region underlaid with the Rotten Limestone. The Warrior river makes its eastern and the Tombigbee its western boundary. The highest land in the county is situated in the northeastern part, within the Drift area, where the main water-sheds are probably some 350 or 400 feet above the river-level. The average elevation of the prairies may be given at about 170 feet above tide, and the line between the Drift belt and the prairies runs northwest and southeast through or near Eutaw, the county-seat. Northeast of this line, the country is broken and hilly; southwest, only gently undulating, with here and there a ridge or hill capped with the sands of the Drift, the relics of a covering which once probably was spread over the whole prairie region.

The bottom lands of the Warrior river, as far as Eutaw, are about one mile in width, and are good farming lands, but are liable to overflow. From this bottom land, there is a rise of seventy-five or eighty feet to a terrace or plain (second bottom or hummock), often five or six miles wide, with brown-loam soil and red clayey-loam subsoil, and from this there is an ascent to the table-lands, sometimes rather abrupt, but more often in several offsets. The soil and subsoil of the table-lands do not differ very materially from those of the terrace below, except that the lower plain is often more sandy than the table-land. Below the red loam, which forms the subsoil of both, are beds of sand and pebbles. The hills which border the table-lands have this red loam often at the surface, and the underlying pebbles also are frequently exposed by the removal of the loam. Red clay and gravelly hills are numerous and characteristic throughout the whole length of this Drift belt.

The prairie region in Greene county has the features which have been described somewhat in detail under Hale and Sumter counties. In the lower part of this county, in what is known as the "Fork," the lands are very much like

those about Livingston, on the other side of the Tombigbee, and consist of calcareous or prairie lands, alternating with sandy ridges, sometimes capped with pebbles. This part of the county has always been celebrated, especially in *ante bellum* days, for its fine cotton plantations.

In its agricultural features, Greene county shows two widely different divisions: the upper, with its brown-loam soils, and the lower, with prairie or calcareous soils, the greater part of the cotton being produced upon the calcareous or prairie lands. No report has been received concerning the prairie lands of Greene county, but that on similar lands in Hale county will apply equally well here.

ABSTRACT OF THE REPORT OF THOMAS J. PATTON, OF KNOXVILLE.

(This report refers to the country drained by Sims' and Buck creeks, tributaries of the Warrior river.)

Three principal soil-varieties are named, viz: sandy, rolling uplands; sandy, loamy bottoms of Sims' and Buck creeks, and the dark sandy loam of the Warrior river bottom. Of these, the sandy uplands are most important, making at least three-fourths of the country about Knoxville. The timber consists of pine, oaks, hickory, ash and gums. The soil is a fine sandy loam, dark on the surface and light colored underneath. The subsoil is generally a red clay, a little sandy, and almost impervious to water, underlaid with sand and pebbles, and occasionally a thin stratum of sand-rock at varying depths. The bottom soils above mentioned are not particularly described, as there is but little difference between the uplands and the bottoms, except that the latter are somewhat more level and more productive, especially for corn.

The land is easily tilled in wet and dry seasons. The chief crops are cotton, corn, oats and potatoes, but the soil seems best adapted to cotton and potatoes. More land is planted in cotton than in all other crops combined. The average height of growth of cotton is three feet, and stimulating manure promotes fruiting more than growth. About one-fourth of the land is turned out, but it is soon covered with a dense growth of pines, and if allowed to rest, say twenty years, it produces well. The hillsides, if neglected, are much injured by washings, but the washings of the top soil, from the slopes, is a benefit to the valleys.

HALE.

Population: 26,553.—White, 4,903; colored, 21,650.

Area: 670 square miles.—Woodland, all, except a few tracts of open prairie; Prairie region, 345 square miles; Gravelly Hills, with Pine, 325 square miles.

Tilled land: 140,072 acres.—Area planted in cotton, 69,995 acres; in corn, 43,254 acres; in oats, 3,671 acres; in wheat, 1,437 acres; in rye, 56 acres; in rice, 16 acres; in tobacco, 16 acres; in sweet potatoes, 1,214 acres.

Cotton production: 18,093 bales; average cotton product per acre, 0.26 bale, 372 pounds seed-cotton, or 124 pounds cotton lint.

Hale county, in its topography, geology, and other natural features, bears a strong resemblance to its neighbor, Perry, on one side, and to Greene on the other. Its upper half, nearly to the latitude of Greensboro, the county-seat, is formed of rolling uplands, which are so characteristic of the Drift belt frequently alluded to. The lower half, on the contrary, is chiefly prairie land, very slightly undulating, and very little elevated, as a rule, above the water-courses. In the uplands, the red loam, which overlies to a depth of fifteen or twenty feet the sands and pebbles of the Drift, forms all the most important soils and subsoils.

The table-lands, and the better class of uplands generally, have a brown-loam soil, with red clay subsoil. This brown loam passes, on the one hand, into a light sandy soil, with long-leaf pine as the prevailing growth, and, on the other, into a stiff reddish soil, with a considerable per centage of clay. The rocks which may underlie this Drift deposit are hidden from view north of Greensboro. In the vicinity of Havana, in the upper part of the county, the pebble and other materials of the Drift are, in places, cemented together, by hydrated oxide of iron, into a rock of considerable hardness. At Havana, this rock forms cliffs along the sides of a deep ravine, and fragments of it, often as large as a good-sized cabin, have been broken off, and have rolled down the glen. Under the overhanging rocks on the sides of the ravine are growing some of the rare ferns of the State. *(a)*

The bottom lands of the Warrior river in Hale county are similar to those described at some length under Tuscaloosa

a Among others, are *Camptosorus rhizophyllus*, Link; *Trichomanes radicans*, Swartz; and *Asplenium ebenoides*, Swartz. The last-named exceedingly rare fern was discovered in this locality by Miss Julia Tutwiler, the only other known locality in the United States being the banks of the Schuylkill river.

county, and are generally well suited to corn, but less so to cotton. The average width on both sides of the river of these bottom lands is about one mile. Above the bottom lands is a level plain of terrace from 75 to 100 feet above the bottom proper, and in places some five miles wide. The soil upon this terrace or second bottom is a sandy loam, which is extensively cultivated, and which produces excellent crops, especially of cotton. From this terrace there is a gradual or abrupt ascent to the table-lands, which have a brown-loam soil and a red-clay loam subsoil, and vary from 300 to 400 feet above the river-level. Beneath the red-loam subsoil are beds of sand and gravel, often of great thickness. In ascending the hills bordering the table-lands these pebbles are passed over along most of the roads a short distance (15 or 20 feet) below the summits. The red-clay subsoil is found also beneath the soil of the lower terrace above spoken of, and this also overlies beds of pebbles and sand, as is the case with the table-lands. This appears to show that the face of the country had already suffered denudation prior to the deposition of the upper portion at least of the drifted materials, and that the more important of the river valleys had already been marked out. The soils of this terrace are, as a rule, rather more sandy than those of the higher table-lands, though otherwise the two have many points of resemblance.

The prairie lands of the southern part of the county are of the usual character, and are well described in the abstract of Mr. Harris' report, given on pages 467-8.

Some of the best of the canebrake lands of the State are situated in Hale county, and the uplands and river lands of the northern part of the county are among the best of their class.

ABSTRACT OF THE REPORTS OF PROFESSOR HENRY TUTWILER, OF GREENE SPRINGS, AND NORFLEET HARRIS, OF LANEVILLE.

(The report refers to the table-lands and bottom lands along Five-Mile creek, in the upper part of the county, and to the prairie and other lands lying adjacent to Big Prairie and Dry creeks, in the southern part. Professor Tutwiler's report describes the upland soils, which are chiefly sandy and red-clay soils, the former being best adapted to cotton, the latter to corn. Reference is made also to the dark sandy soil of Five-Mile creek and the Warrior river. The report of

Mr. Harris describes the most important soils of the canebrake region. These are the first and second bottom lands of Big Prairie and Dry creeks, and low slough lands, and, in addition, the rolling-prairie lands of black and brown colors.)

The most important are the sandy and the red-clay soils, which make two-thirds of the land about Havana, the first a light-colored sandy loam, the latter a rather heavy clay loam of a brown to red color. The natural growth upon these consists of oaks, hickory, gum, short-leaf pine, poplar, etc. The subsoil is a red-clay loam, which, on cultivation, becomes like the surface soil. This rests upon beds of sand and gravel, and in certain localities upon the conglomerate above alluded to. Tillage is rather difficult in wet seasons, and the red soil also is difficult of tillage in dry weather, as it is disposed to crack. They are both naturally well drained.

The red lands are somewhat difficult to till in dry seasons, the chief crops being cotton, corn, oats, and potatoes. The sandy land is best suited to cotton; the red land to corn. About one-half of the land is planted in cotton, and the average height of growth is three to four feet. Nearly all the turned-out land has been reclaimed within the last few years, and yields well for a short time. The hillsides are injured, but the valleys are generally benefited by washings.

A wet May is very injurious, as the land cannot be worked and the crabgrass gets the start of the farmers. Even more disastrous is excess of rain in July and August, when the cotton is fruiting most. When these months are hot and dry, immense crops of cotton are always made.

The three chief varieties of soil described by Mr. Harris, are as follows:

Rolling prairie lands of black or brown colors, which make about 50 per cent. of the area about Faunsdale. This soil, intermixed with those described below, make up the canebrake country for many miles in each direction. The prevailing timber consists of the various species of oaks, ash, hickory, sweet and sour gums, etc. The soil is a dark calcareous clayey loam fifteen to eighteen inches in thickness, resting upon a subsoil of a grayish or neutral-tinted clay, putty-like, but apparently quite fertile, since, when thrown up out of ditches, it produces a fine crop the first year. This clay is almost impervious, containing no pebbles or concretions, and is underlaid with a blue lime rock at twenty feet depth (Rotten Limestone). In wet weather cultivation is difficult, but in dry weather easy, and grass and weeds are then easily killed. This soil may be classed as early and warm when well-drained.

The next soil in importance is that of the rolling prairie lands of yellowish or red colors, commonly called post-oak prairies. These make up perhaps 35 per cent. of the country about Faunsdale, and have about the same distribution as the black prairies before mentioned. The timber is much the same as that upon the other land, with the exception that the post oak is the most characteristic tree. The soil is a clay loam, stiff and somewhat putty-like when wet, of buff, yellow, brown, and mahogany colors, and more particularly chocolate-colored in places. Its thickness is from 18 to 20 inches before change of color to that of the subsoil, which is heavier than the surface soil, being a stiff grayish clay, yellowish in places, and almost impervious. This subsoil contains no pebbles or concretions, and is under-

laid with a blue-lime rock, like the black soils (Rotten Limestone), at a depth of twenty feet. In wet weather this soil is difficult to cultivate, as it is very sticky; in dry seasons, however, it crumbles easily and is readily tilled, being early and warm and usually well-drained, as the surface is quite rolling.

Lastly, a loose walnut prairie land makes up a small proportion of the country about Faunsdale. The growth is nearly the same as that upon the other lands described, with some cedar and black walnut in addition. This soil is a fine, loose silt or prairie of whitish to gray color, often three feet in thickness, with a subsoil of a white, heavy, putty-like clay, almost impervious to water. It contains occasionally a few rounded pebbles, and is underlaid, like the others, with the Rotten Limestone. These lands are somewhat difficult to cultivate in wet seasons, but are the easiest of all in dry weather, and are the best corn lands. The soil is late and not so well drained as the others. All these soils are planted in corn, cotton, oats, etc., the first two being best suited to cotton, the latter to corn. The post-oak land is perhaps the best for cotton, and, where a farmer has several varieties of soil on his place, two-thirds of the post-oak land are put in cotton. Two-thirds of the open ground of the black prairies also are put in cotton, but very little of the walnut lands is ever so planted. From three and a half to four feet is the most productive height of stalk.

The post-oak land is thought to respond best to fertilizers. At present all of the cleared land is in cultivation; formerly a large proportion (10 per cent.) was turned out. When reclaimed it takes usually about two years to conquer the weeds and grass, and the lands do not, therefore, produce as well the first year, but after that, for several years, the yield is nearly as great as on fresh land. All these lands, where at all rolling, wash badly on the slopes, and the damage from this cause would be very serious but for the fact that this is prevented at once by hillside ditching, and in a few instances by horizontalizing also. The valleys are not injured, but, on the contrary, are much improved by the washings from the higher levels.

MARENGO.

Population: 30,890—White, 7,276; colored, 23,617.

Area: 960 square miles.—Woodland, all, except a few square miles of open prairie; Prairie region, 480 square miles; Oak and Hickory Uplands with Long-leaf Pine, 380 square miles; Post-oak Flatwoods, 100 square miles.

Tilled land: 169,097 acres.—Area planted in cotton, 80,790 acres; in corn, 43,876 acres; in oats, 6,574 acres; in sugar-cane, 43 acres; in tobacco, 43 acres; in rice, 26 acres; in sweet potatoes, 1,138 acres.

Cotton production: 23,481 bales; average cotton product per acre, 0.29 bale, 414 pounds seed cotton, or 138 pounds cotton lint.

The northern half of Marengo county is formed by the

rocks of the Cretaceous formation, and the southern by those of the Tertiary, giving thus a considerable variety of geological features, while the soils overlying and more or less modified by these different formations exhibit corresponding varieties.

The Cretaceous formation is represented by the beds of the Rotten-Limestone group, and the physical features and soils peculiar to this group are sufficiently characteristic. The surface configuration of this territory is nearly level, or at most, gently undulating, especially where the Rotten Limestone forms or is very near the surface, broken by irregularly distributed ridges capped by the sands and pebbles of the Stratified Drift. The soils vary from the stiff calcareous clayey or prairie soils of the Rotten Limestone proper through all gradations to the light sandy loams of the superficial beds. Where the Rotten Limestone itself forms the soil, it is a heavy clay soil, usually of a dark tint, with a subsoil of a yellowish-green color, and likewise of heavy nature. The color of the soil varies from gray to black, according to the amount of vegetable matter present. Where the rock itself is sufficiently near the surface the soil is usually destitute of trees, and constitutes the bald prairies, which are irregularly scattered throughout the territory.

A second variety of soil is known as the post-oak soil. This is a heavy sandy clay of reddish or yellowish colors, usually timbered with a prevailing growth of post oaks and short-leaf pine. Analyses of these several varieties of soil are given under the regional description. The sandy ridges previously mentioned are found throughout this region, but are more abundant and continuous for greater distances near the southern border of the limestone area. The town of Dayton is situated upon such a ridge, and as it is approached from the north the surface becomes more broken, and the black or dark-colored heavy prairie soils of the Rotten Limestone give way to a reddish, somewhat sandy soil, with a growth of post oaks and short-leaf pines, beyond a narrow strip of which come the sandy soils of the ridge proper.

Between Dayton and Linden is a belt of hilly land, in which a sticky, yellowish clayey soil (Hill Prairie) is quite common, and which has a characteristic growth of short-

leaf pine, hickory, and red and post oaks. The underlying rock, wherever seen in this strip between Dayton and Linden, is a hard yellowish limestone containing Cretaceous fossils. The whole aspect of the country, its soils, timber, etc., resembles the Chunnenugga ridge at Union Springs.

South of the latitude of Linden, and extending east and west across the county, is a belt five or six miles wide, of a low, gently undulating country called Flatwoods, or Post-oak Flatwoods. These Flatwoods rest upon a heavy grayish clay filled with reddish spots, which, in wet weather, becomes so tough and intractable that the roads through it are almost impassable. By reason of their unfavorable physical composition these lands are comparatively little cleared and cultivated, though the analysis of a specimen of the clay from near Linden, given on page 280, will show that it is by no means deficient in the elements of a good soil, except in the proportion of lime, which is small. Southward still of this, to the Clarke county line, the lower beds of the Tertiary formation, consisting of dark-colored clays and sands (with which are interstratified beds of lignite and of shell marl containing greensand), underlie the superficial beds of sand and loam which in general constitute the soil and subsoil throughout this entire section. The lignite beds are occasionally of exceptional thickness, one on Landrum's creek being between six and seven feet. Of great importance agriculturally are the beds of shell marl spoken of. One of these is exposed at the bluff of Nanafalia landing, and makes its appearance at the surface at several points eastward, where its intermixture with the surface loam has given rise to a kind of prairie or limy soil of great fertility. Beaver creek flows along the foot of the hills running parallel with these marl outcrops, and hence the very superior quality of the lowlands which border it.

Between the Beaver creek lands and the Post-oak Flatwoods rise some of the highest hills of the county, the Rembert hills, with an elevation of 350 feet or more above the river-level. These hills are covered with the red-clay loam and have a fine oak growth. Where the Linden road crosses them there stand the handsome residences of the planters, who cultivate the river lands which they overlook.

In Marengo county and the northern part of Choctaw the river lands are usually from one-half to three-quarters of a mile wide, of river front or high land, with a fertile sandy-loam soil, all in cultivation and occupied by some fine plantations. In the bends there is often a much greater width of this front-land, and at the Turner place, above Tuscahoma, it is two or three miles. Back of this high land is the swamp, one to three miles wide, heavily timbered with sweet gum, holly, swamp chestnut, oak, elm, scaly-bark hickory, and white oak. The swamp is entirely uncultivated and traversed with sloughs, and the roads across it, even in dry weather, are far from good, and in the winter are almost impassable. This seems to be the general nature of the river lands throughout the region in which the lowest Tertiary or lignitic strata make the country.

The brown-loam uplands of the southern half of the county south of the flatwoods are in all respects similar to those of other parts of the State, and require no special mention.

Agriculturally, Marengo is similar to the adjacent parts of Dallas, Perry, Hale, Sumter, and Greene counties, in the prairie region, and Wilcox and others, in the Oak and Hickory Uplands. The report of Rev. Mr. Stickney gives all the needed details concerning cotton culture in the principal cotton-producing part of the county, viz: the canebrake.

ABSTRACT OF THE REPORT OF REV. W. A. STICKNEY, OF FAUNSDALE.

(The uplands described are the rolling and flat lands, with partly a loose black-prairie soil, partly a mulatto or post-oak soil, and partly a light ashy-colored cedar-glade soil, all lying within the drainage area of Cottonwood and Powell's creeks.

The bottoms are late, and hence, the young plant is ravaged in its very prime by the caterpillar, and these pests have not for years permitted the climate to discriminate between the uplands and the bottoms. This region is known as the Canebrake. The creeks are only drains or artificial canals, perfectly dry in summer, except in holes. The higher lands yield better in wet years; the flat or bottoms best in dry years. The three kinds of soil most prevalent are: First, the loose black-prairie soils, level and rolling, much of it lying on the larger drains and their tributary ditches, and in the main protected from injurious overflow; second, the mulatto or post-oak stiff soil, mostly upland; and third, light-gray cedar hummock soil, also upland. Of these the most important is the black-prairie soil, which, how-

ever, constitutes less than half the lands of the region under discussion; but all these soil-varieties are so intimately associated with each other that in a few feet square all may be seen. Occasionally a large unbroken body of the prairie soil will be met with. The principal trees are the various oaks, scaly bark, ash, hackberry, cedar, sweet gum, red, white, and slippery elm, walnut, hickory, poplar, cottonwood, papaw, buckeye, persimmon, dogwood, cane, and dwarf palmetto. The physical characters of the soils of course change with the soil-variety, and these are the loose, limy prairie soils, the stiff, sticky clayey soils, etc., of mulatto, yellow, blackish, and black colors, alternating or mixed. The average thickness may be from five or six feet to as many inches, the white, Rotten Limestone very commonly outcropping on the uplands. The subsoil is the same as the soil, the cistern lime-rock underlying all the Canebrake soil. In exceptional spots the soil contains white rounded pebbles of quartz. The tillage is not difficult if the soil is stirred at short and opportune intervals by the plow. When well-drained the soil is early; when ill-drained the bottoms are unproductive.

The chief crops in the Canebrake are cotton and corn, and the soil seems to be about equally well adapted to each; if any difference, it is in favor of corn. Two-thirds of the cultivated area is, however, in cotton. The stalk varies in height from two to four or five feet, the latter height being best if the plant is not molested by the worm. When well worked, and when overtaken by a rainy season, the plant is inclined to run to weed, for which no remedy is known. Dirt thrown too high upon the stem (*a*) is regarded as an obstacle to bolling and very injurious when the dirt is hot. In favorable seasons the fresh land will produce from 1,200 to 1,600 pounds of seed-cotton to the acre (barring the caterpillar). The average for a 475 pound bale is 1,600 pounds. The staple is of the best quality.

As to the yield, after long cultivation it is difficult to speak with precision. In one of the favorable years some of our land, worked consecutively for 40 to 50 years without manure, will yield from 1,200 to 1,600 pounds per acre, while the thin uplands will hardly turn out 300 to 400 pounds of seed-cotton. The staple from old land is usually thought to be shorter than that from the fresh land. The most troublesome weeds are the morning-glory, crab and other grasses, and hog weeds. Chicken corn is now overrunning us from bad culture. From 10 to 20 per cent. of the uplands have been turned out in some places, and the amount is greatly on the increase. When these lands are again taken into cultivation they produce well if they have been fertilized in the meanwhile by common pea-vines or clover; otherwise, poorly. The soil washes badly on slopes, and the injury is very serious and constantly on the increase because of negligence. Where the ditches are kept cleaned out the damage to the valleys is very slight. Since the war very little has been done toward checking this evil. Before the war the system of horizontalizing was very perfect, but the art is fast being lost.

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a This high dirting in the midst of the plant's fruiting will commonly stimulate it to extra growth, but check fecundity for the time being, as if the two growths were too much at the same time. I have heard of breaking the roots by siding with a long colter plow, as a means of cutting off the excessive supply of sap, thus restraining weedy growth and favoring fruiting.

PERRY.

Population: 30,741.—White, 7,150; colored, 23,591.

Area: 790 square miles—Woodland, all. Gravelly Hills, with Long-leaf Pine, 465 square miles; Prairie region, 325 square miles.

Tilled land: 167,666 acres.—Area planted in cotton, 74,303 acres; in corn, 48,132 acres; in oats, 6,093 acres; in wheat, 440 acres; in rye, 70 acres; in rice, 27 acres; in tobacco, 24 acres; in sugar-cane, 20 acres; in sweet potatoes, 1,107 acres.

Cotton production: 21,627 bales; average cotton product per acre, 0.29 bale, 414 pounds seed-cotton, or 138 pounds cotton lint.

A belt composed of thick beds of sand and pebbles covers all the northern part of Perry county as far south as the line connecting Greensboro and Marion. Within this area, the natural features are those characteristic of the Stratified Drift everywhere. The face of the country is somewhat broken, though there are no great elevations, the main water-sheds being about three or four hundred feet above the level of the Cahaba river, which receives, directly or indirectly, all the drainage of the county. Upon the highest land, it is usual to find the soil somewhat sandy, and supporting a growth chiefly of long-leaf pine. Along the slopes, and at lower levels generally, a brown-loam soil is very widely distributed, and the timber upon it consists of the various species of upland oaks, hickory, and short-leaf pine, with occasionally the long-leaf species. Beneath this brown loam there is a rather stiff red loam, usually called red clay, which is underlaid with pebbles and sand at varying depths. A not uncommon thickness for the red clay or loam is twenty or twenty-five feet. This part of the county, while not enjoying the reputation of the lower part, has still some excellent farming lands. The level table-lands, which have an average elevation of two hundred or two hundred and fifty feet above the water-courses, are nearly all cleared, and have been long in cultivation. In some cases, from neglect or careless cultivation, they are badly worn or turned out, but when reclaimed and properly

treated, they are among the most desirable lands in the county. Wherever the Drift forms the surface, there is no lack of the best of drinking water to be had from wells and springs. Marion, the county-seat, and a great educational center, stands on the southern limit of this Drift belt, overlooking the prairies, which stretch away for twenty miles toward the south in a gently undulating, trough-like plain, lying between the Drift hills on the north and similar ones on the south.

The Rotten Limestone formation on the Cretaceous forms the substratum throughout the prairie or Canebrake country, and the topography and soils show very little variation. The prairie soil proper is a stiff, putty-like soil, originally gray, but usually of dark to black color (from organic matter). This soil can scarcely be said to have a subsoil, since it rests directly upon the Rotten Limestone, from which it is derived. The thickness varies greatly, the bare rock being exposed in many places without any soil at all, and in the sloughs and low places there is often several feet thickness of alluvial or made soil. The uniform level of the prairies is interrupted at intervals by low hills or knolls, which are capped with the sands and other beds of the Drift. In many cases it appears that these elevations owe their existence to the protection afforded by these materials. Where the sands and loam of the drift are mingled with the calcareous soils of the prairies, there is formed what is universally known as the post-oak Prairie soil, which is a yellowish to reddish material of considerable fertility, characterized by the prevalence of the post oak among its timber trees. These are sometimes also distinguished as "woods prairies." Upon the sandy ridges and knolls of this section are situated many of the towns and settlements of the county, the abundance of good water and freedom from mud being the strong attractions.

The belt of prairie country underlaid with the Rotten Limestone has been given as about eighteen or twenty miles wide. In the extreme southern corner of the county, a bed of rather hard crystalline limestone is found resting upon the Rotten Limestone, and as it is tolerably resistant to denudation, the region of its occurrence is somewhat more

broken and rugged than that where the Rotten Limestone is the surface rock. In the eastern part of the State, this hilly region is known as the Chunnenugga ridge. The soil, where the overlying Drift sands are in great thickness, is sandy and of no great fertility, but where, on the slopes, these materials have been partially removed by erosion, the influence of the limestone is felt, and the soil becomes a calcareous loam of considerable fertility, approaching in character the soils of the post-oak prairies, which, indeed, are formed in a very similar manner. In the neighborhood of Marion, which is upon the extreme southern limit of the upper Drift belt, the bluish micaceous clayey rocks of the lowest division of the Cretaceous formation may be seen in the deepest cuts and gullies, but they have very little influence upon the soils or topography, since they are covered with thick beds of the Drift, and are not seen at all, even in the deepest cuts, much north of Marion.

Agriculturally, this county shows two distinct characters—brown-loam uplands in the northern half, and prairie in the southern. Notwithstanding the greater inherent fertility of the latter region, the brown-loam lands are probably of more importance in the production of cotton.

ABSTRACT OF THE REPORT OF H. A. STOLLENWERCK, OF UNIONTOWN.

(The soils described are the black slough lands, the black and yellow post-oak lands, and the uplands.)

The uplands soils are considered the most important, and are distributed over the canebrake country in patches, making more than half of the tillable lands. These uplands occupy the slight elevations of the prairies, and the soils grade almost imperceptibly into those of the prairies. Intermediate between the two are the post-oak soils. The upland soil proper is a sandy loam, with subsoil of yellow clay. The color varies from light gray, through brown, to almost black, and the underlying rock is the Rotten Limestone, which is everywhere found at depths varying from one to twenty feet.

The chief crops produced are cotton and corn, the black or slough lands being best suited to corn, and the uplands to cotton. About two-thirds of the tilled land is in cotton, which attains the average height, when most productive, of four feet. About one-fourth of the land originally in cultivation now lies turned out, and as it is rolling, the soil washes away, and the reclaimed land is, on this account, not very productive. The valleys also are often injured to the extent of ten per cent. by the washings from the uplands. Some efforts have been made, by horizontalizing and hillside ditching, to check the evil, and with very good success.

DALLAS.

Population: 48,433.—White, 8,425; colored, 40,008.

Area: 980 square miles.—Woodland, all, except a few square miles of open prairie; Prairie region, 830 square miles (Rotten Limestone or Canebrake, 700, Hill Prairies, 130); Gravelly Hills, with Pine, 150 square miles.

Tilled land: 207,404 acres.—Area planted in cotton, 115,631 acres; in corn, 46,542 acres; in oats, 8,260 acres; in wheat, 71 acres; in tobacco, 13 acres; in sugar-cane, 18 acres; in sweet potatoes, 2,256 acres.

Cotton production: 33,534 bales; average cotton product per acre, 0.29 bale, 414 pounds seed-cotton, or 138 pounds cotton lint.

Dallas county is traversed by the Alabama river, which flows through it from northeast to southwest. Its principal tributary, the Cahaba river, flowing southward, falls into it at the old town of Cahaba. The bottom lands of the Alabama river are sandy fertile loams, which are especially suited to the cultivation of corn. A second bottom, or terrace, often five or six miles wide, sometimes altogether on one side of the river, sometimes equally divided by the river, adjoins the true bottom lands. This terrace is generally sandy, and is almost a level plain. The soils are gray or light-colored, and are well suited to cotton. This terrace has an average elevation above the river of about 100 feet. From this out to the summits of the various dividing ridges there is a rise more or less gradual to the elevation of 350 or 400 feet, which may be taken as the average elevation of the table-lands above the river.

The geological structure, upon which depend the character and distribution of the soils, is simple. The underlying rocks are the strata of the Cretaceous formation, consisting, in the middle and northern part of the county, of an impure limestone, known as the Rotten Limestone, and in the southern of a yellowish, often crystalline limestone, and a bluish sandy marl. Over all these have been deposited beds of varying thickness of sand, pebbles, and loam of the Stratified Drift formation. From all these beds and their intermixtures the surface soils of Dallas county have been

derived. In the northern part of the county, above Summerfield, the underlying rocks are completely hidden from view by the surface beds of Drift, and the loams of this formation furnish the soils and subsoils, which have the usual variety common in such localities. The best of these soils is a brown loam, with red-clay loam subsoil, resting on sand or gravel. Its timber is a mixture of the upland oaks and hickory. With admixtures of sand the soil changes in character, and the timber with it, long-leaf pine being added to the growth and black-jack oak becoming prevalent. The extreme in this direction is seen in the upland pine woods, which occupy many of the pebbly and sandy slopes of the northern portion of the county. Several analyses, representing these soil-varieties, have been given of soils collected in the neighboring county of Autauga (see page 247.)

Going southward from Summerfield this brown-loam region, which is also universally known as the hilly country, extends to within two miles of Selma, where the river terrace is reached. As already stated, this terrace has a superficial covering of sand resting upon the Rotten Limestone, which is exposed wherever the streams have cut their channels a few feet below the general level. Within two miles of Selma, in the drainage area of Little creek, the black prairie soil is crossed nearly up to the city limits, and near the river the sands form the surface. From Selma to Cahaba is the same sandy river plain, the monotony of which is only broken in the vicinity of the streams.

Westward from Orrville to the limits of the county, and also northwestward, is a prairie or Canebrake country of the usual character: a gently undulating region with no great elevations, having the Rotten Limestone at or very near the surface, yielding calcareous soils of gray to black colors, affording splendid hard roads in dry seasons, but almost impassable muds in the winter. Here and there throughout the Prairie region are slight elevations capped with sandy loams (sometimes associated with pebbles) of the Drift formation, apparently the remnants of a once universal covering of these materials. The mingling of these loams with the calcareous soils give rise to the formation of red sandy prairie soils, upon which the post oak seems to be

most at home. On the eastern side of the river the same characters are to be seen out to the Lowndes county line. The sandy ridges, which traverse the prairies, appear to be quite as characteristic of this region as are the prairie soils themselves. Orrville is upon one of these sandy belts. Many of the details concerning these soils and their composition are in the description of Perry and Marengo counties, and in Part I, where several analyses of typical prairie soils have been presented (see page 270).

The yellowish, often cystalline limestone, mentioned as underlying the lower part of the county, is, like the Rotten Limestone, covered with the beds of the Drift formation. These are, however, much more universally present here than in the central part of the county, where, as has just been said, they simply cap the ridges which traverse the prairies. The existence of hard ledges of limestone, alternating with softer strata, greatly influences the topography of this part of Dallas county. The table-lands, or high level country, at an average elevation of 350 or 400 feet above the river, have the brown-loam soils and red clayey loam subsoils of the best uplands resting on beds of sand and pebbles. The thickness of these beds may be put at 25 or 30 feet in the lower part of the county. Toward the streams these table-lands break off, usually quite abruptly, by reason of the hard limestone ledges alluded to, giving rise to the steep lime-hills of this section. The soils derived from these calcareous rocks are mostly yellowish calcareous loams, which at a certain stage of moisture form the most tenacious of muds.

The bottom soils of the creeks of this section are sandy and more or less affected by the lime of the neighboring hills, and as a consequence make fine farming lands. Of this character are the bottom lands of Cedar, Dry Cedar, and Mush creeks. In these bottoms, however, there are all gradations between black, limy, and loose sandy soils, according to locality. The villages of Carlowville and Pleasant Hill are situated upon plateaus with brown-loam soils, timbered with the usual variety of upland oaks. A descent of 25 to 30 feet from the level of these plateaus brings one to the calcareous rocks which underlie this part of the coun-

ty. The lowlands along Dry Cedar and Mush creeks are from two to three miles wide, and are generally cleared and in cultivation, except where occasionally worn land has been turned out. Pebbles, often of large size, are commonly found along the slopes of the plateaus above alluded to.

Dallas produces more cotton than any other county of the State. To this its large area (980 square miles) contributes in an important degree, but its large proportion of rich prairie or Canebrake and Alabama river lands would place Dallas county in the first rank in cotton production.

ABSTRACT OF THE REPORT OF J. F. CALHOUN, OF MINTER STATION.

(This report refers to the lands lying between Pine Barren and Dry Cedar creeks on the north and south, and between the lines separating ranges 10 *and* 11 *and the Alabama river.)*

The soils in cultivation in cotton are: 1, sandy uplands; 2, rolling or hilly prairie; and 3, creek-bottoms.

The most important of these soils is that of the uplands, which makes at least one-half of the region described. The timber consists of a species of oak, except pin oak, chestnut, hickory, gum, short-leaf pine, and chincapin. The top soil is usually a fine sandy loam of a gray color, six inches thick, resting upon a subsoil of coarse red clay, which sometimes, though rarely, contains rounded pebbles of quartz. Beds of sand and gravel underlie the subsoil at the average depth of 10 feet. This soil is easily tilled, except in very dry seasons.

The rolling-prairie soil makes about one-eighth of the region described, not occurring in continuous tracts, but cropping out at different places. The timber is mostly post-oak, hickory, and black-jack. The top soil is a somewhat heavy shell prairie of a gray color, eight inches thick, with a rather heavier subsoil of lighter color than the top soil, very hard and waxy. The subsoil contains shells and the fragments of the lime-rock, which forms the general substratum of the section at varying depths. In wet seasons the tillage is difficult, and the lands are rather late and cold.

The creek bottoms, which border the two large creeks mentioned, and also the numerous smaller tributaries of the same, make about three-eighths of the lands of the section. Their natural timber growth consists of white and pin oaks, beech, hickory, ash, etc. The top soil is a coarse, sandy, often gravelly loam, sometimes a heavy clay loam; colors, gray to brown; subsoil, usually a white, stiff, crawfishy clay. White pebbles of quartz are not uncommonly found. The subsoil rests mostly upon sands, and its tilling qualities are difficult in wet seasons. These lands are late, cold, and usually ill-drained.

The rolling prairies are best suited to grain crops, very little cotton being planted; the other two to cotton, which makes about three-fourths of the cultivated crops upon them. The height of stalk varies from 2½ to 3 feet, but is most productive at three feet. The rolling prairies, after a few years'

cultivation, are injured badly by washes, and soon rust the cotton. Very little of the uplands is turned out, because the use of fertilizers has brought it into demand. The land seems to be very slightly benefited by lying out. A large proportion of the hilly prairies is abandoned, because thoroughly worn out and washed away. The subsoil is not usually washed off. The bottom lands are nearly all in cultivation, and are improved by resting, unless soured by lack of drainage. The uplands and rolling prairies are injured by washings, but the valleys adjoining are improved. Horizontalizing and hillside ditching are practiced with success in the uplands; in the hill-prairie region they are very little practiced, because of the very broken character of the country.

WILCOX.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

BUTLER.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

LOWNDES.

Population: 31,176.—White, 5,645; colored, 25,531.

Area: 740 square miles.—Woodland, all, except a few square miles of open prairie. Prairie region, 740 square miles (470 Rotten Limestone and 270 rolling or Hill Prairies). In the Prairie region a large area of the uplands are brown sandy loams.

Tilled land: 181,272 acres.—Area planted in cotton, 98,200 acres; in corn, 41,169 acres; in oats, 3,630 acres; in sugar-cane, 201 acres; in sweet potatoes, 1,004 acres.

Cotton production: 29,356 bales; average cotton product per acre, 0.30 bale, 429 pounds seed-cotton, or 143 pounds cotton lint.

In general, the agricultural features of Lowndes county are similar to those of Montgomery, which adjoins it on the east. The underlying country rocks are beds of the Cretaceous formation, and these are in places partly or wholly covered with the latter beds of sand, gravel, clay, and loam of Stratified Drift. Most of township 16, in the limits of this county, lies within the river plain, and is made up chiefly of the first and second-bottom lands. These have a general elevation of thirty or forty feet above low-water mark, and are approximately level. The soils are mostly sandy, but very productive, especially in the first bottoms,

and being subject to overflow, are usully planted in corn, of which crop forty bushels to the acre are often made. These bottom lands, while prevalently sandy, still show the beneficial effects of the calcareous substratum. In many places there is a slight slope away from the immediate bank of the river, the foot of the first terrace being often as much as ten or fifteen feet lower than the actual river bank.

About the line between townships 15 and 16 there is a tolerably abrupt rise of 175 or 180 feet to a level, which, between Lowndesborough and Manack's station, is from one to two miles wide. This terrace has the Drift and Loam as surface materials, but the calcareous beds of the Cretaceous formation crop out in many places along the hillsides, separating the river hummock from the first terrace, producing limy soils. Pebble beds also occur along this slope, but very few are seen as low as the hummock proper, except upon the summits and the sides of the little knolls, which rise above the general level of the river hummock. The soil of the first terrace above spoken of is a sandy loam of brown to gray colors with a subsoil of red-clay loam, and is in all respects similar to the soils and subsoils of the Drift belt in other parts of the State.

From this first terrace there is a second rise of about 75 feet to the level of the Lowndesborough plateau, which has about the same elevation as the table-lands of Autauga county (some 250 or 260 feet above the river). Between Lowndesborough and Hayneville this plateau is five or more miles in width, and has all the characters of the table-lands of this latitude. The soil is a brown loam of considerable fertility, with a red-clay loam subsoil, which is in many places underlaid with beds of pebbles. The analysis given on page 247 of the table-lands soil of Autauga county will show fairly the general characters of this class of soils. The level nature of the land and the abundance of good water to be had everywhere in the sands and pebbles combine to make this and other plateaus of similar kind among the most desirable as farming lands and as places of residence.

Near the line between townships 14 and 15 there is a descent, going southward, of some 120 feet (usually in at

least two terraces) to the general level of the prairies. Thence to about the line between townships 12 and 13 the black prairies continue with very little variation, and with approximately the same general level. South of this line the strata of the Upper Cretaceous formation, consisting of ledges of hard limestone, alternating with softer and more clayey beds, make the country down to the line of Butler county. Throughout this region the surface is much broken, the country being a succession of steep and sometimes rocky hills, with clayey, calcareous soils. In wet weather the soil becomes a very tenacious mud, which, together with the steep slopes of the hills, makes the country almost impassable for vehicles. The southwestern corner of the county, which is of this character, has the name of "Little Texas."

In a general way, this hilly country makes the water-shed between the north and south flowing streams, the former being tributaries of Manack's and Big Swamp creeks, the latter of Sepulga river and Cedar creek. One of the tributaries of the last-named stream, viz: Dry Cedar creek, drains this hilly country toward the north. The bottom lands of most of these streams are excellent farming tracts, but are in general best suited to corn.

The principal soil varieties have already been mentioned in passing. These are the sandy loam soils of the table-lands, the dark loam soils of the bottoms, and the calcareous soils of the prairies and lime-hills, and will be described more in detail in the following abstract.

Although the whole of Lowdnes county lies within the Prairie belt, yet there is a fair proportion of upland soils, which are derived from the transported beds of the Drift. The agricultural characters of the county are thus quite varied, but are quite similar to those of the corresponding regions in other counties adjoining.

ABSTRACT OF THE REPORTS OF W. M. GARRETT, OF MOUNT WILLING, AND P. T. GRAVES, OF BURKEVILLE.

(The lands described are within the drainage area of Pintlala and Cedar creeks.)

The upland soils vary from black prairie on the north to sandy loams on the south. In dry seasons the uplands are not so sure of a good crop as

are the lowlands, but with moderately wet weather the former are far more productive. The red table-lands have a clay loam soil of a brown to reddish color, ten to eighteen inches in thickness, with a subsoil of red clay or loam, in the main free from pebbles and sand, and resting at a depth of ten to eighteen feet upon a bed of gravel and sand. The soil is usually easily tilled, warm, and well drained. The black prairie lands have a black or dark-colored soil of eight to ten inches in thickness, passing gradually into the light-colored limestone, and have the usual characters of the prairie soils. The bottom soils are of several kinds, according to the surrounding uplands, and need no particular description.

The principal crops are cotton and corn, the latter being most productive on black lands, the former on sandy lands; but the red lands produce both crops equally well. From two-thirds to three-fourths of the tillable land is devoted to cotton. Cotton generally grows from three to five feet high, but in wet seasons it runs to weed and can only be prevented by shallow culture and the free use of manure. Very little land is turned out; but when it is level it is easily restored to its former productiveness. The hillsides are somewhat injured by washings; the valleys are also sometimes injured, if the deposit is deep and composed chiefly of sand.

AUTAUGA.

(See "Gravelly Hills region.")

MONTGOMERY.

Population: 52,356.—White, 13,457; colored, 38,899.

Area: 740 square miles.—Woodland, all, except a few square miles of open prairie; 565 square miles of level and hilly prairies, of which 75 square miles has a coating of Drift; 100 square miles of Sandy and Pebbly Hills, with pine.

Tilled land: 241,570 acres.—Area planted in cotton, 112,125 acres; in corn, 62,303 acres; in oats, 4,895 acres; in wheat, 58 acres; in sugar-cane, 174 acres; in sweet potatoes, 1,720 acres.

Cotton production: 31,732 bales; average cotton product per acre, 0.28 bale, 399 pounds seed-cotton, or 133 pounds cotton lint.

The Tallapoosa and Alabama rivers, where they form the northern boundary of Montgomery county, mark very nearly the line between the Rotten Limestone and the underlying Lower Cretaceous beds. These rivers, especially the Alabama, have wide hummocks or second bottoms above overflow and bottom lands of great fertility. The second bot-

tom, or old river plain, is from two to four or five miles wide, and in some places, as between Benton and Montgomery, is very level, and where not too much covered with the alluvial sands is a fine farming region. Beyond the river plain is a ridge of sand, pebbles, and clay of the Stratified Drift, which gradually slopes away to the level or gently undulating prairie lands of Rotten Limestone, which form a belt across the middle of the county. In this belt the materials of the Stratified Drift are, in places, wholly wanting and in places present in limited quantity, where they are seen capping the small hills of the otherwise level prairies. Southward, beyond the Black or Canebrake belt, we encounter another accumulation of these Drift materials overlying the sandy marls of the Ripley or Chunnenugga group of the Cretaceous formation.

The sands and laminated clays of the lowest division of the Cretaceous formation, while often exposed on the river bluffs, do not come to the surface in Montgomery county, and therefore take no part in the formation of its soils. The next overlying series, however, the Rotten Limestone, is here, as elsewhere, of great importance agriculturally, as being the basis of the prairie lands, which are among the most valuable in the county. The Drift, however, with its red and yellow loams resting upon beds of sand and gravel, forms all the fine upland soils which are interspersed with the prairie soils, and which prevail in the southern part of the county.

The greater part of the cotton, and indeed of all the crops, is made in prairie belt and along the first and second bottoms of the river and of the numerous streams flowing into it. These bottom lands are of great variety, some being stiff prairie soils, others light and sandy, and this applies as well to the bottom lands of the river itself, where the greatest variety may be seen. The abstract given below will show in detail the nature and characteristics of these various soils. In its agricultural features Montgomery very closely resembles Lowndes. The cotton, as soon as ginned, is hauled to the city of Montgomery, and there sold.

ABSTRACT OF THE REPORTS BY THOMAS W. OLIVER, OF MONTGOMERY, AND J. A. CALLOWAY, OF SNOWDOUN.

(This region reported upon lies, as to the lowlands, along the small streams tributary to the Tallapoosa river and along the waters of Ramer and Catoma creeks.)

The uplands are the rolling and level table-lands adjacent to these streams and the prairie lands which occupy the lower levels in the same region. The lowlands are often overflowed, necessitating late planting of the cotton, which is thus liable to be destroyed by the caterpillar before it has had time to mature a crop. For this reason the uplands are generally preferred for cotton where the soil is at all suitable. The chief varieties of soil are the red lands, which are the upland loams, the post-oak and black-prairie soils, and the light-gray sandy soils lying between the red lands and the river bottom. This last occupies a narrow belt only. To these may be added the dark loam and the light sandy soils of the smaller streams above mentioned.

The most important of these soils is the prairie soil, which is found in patches all over the central portion of the county, and which is the main one of the Black belt throughout the State. This soil occupies from a half to three-fourths of the area described, and has a natural growth consisting of post-oak, hickory, hawthorn, wild plum, ash, etc. It has the usual heavy prairie soil of a gray to black color. The post-oak or timbered prairie soil is often of reddish color, and is thought to be the result of the admixture of the overlying loam with the calcareous matter of the Cretaceous rocks. On the black lands the subsoil is a jointed clay, white and chalky, overlying a blue marl. (*a*) The subsoil often contains lime nodules of irregular shape. When properly broken up, the soil on exposure and drying crumbles down and is very easily tilled, but in wet weather it is stiff and difficult to work.

The red-loam land is timbered with oaks, hickory, short-leaf pine, and the bottoms with poplar. gum, magnolia, etc. The soil is a sandy loam of different degrees of stiffness, and of colors varying from brown to red, according to the length of time cultivated. At eight or ten inches the color changes to that of the subsoil, which is generally a fine red loam, about one-third sand, friable when exposed, and darkening when mixed with vegetable matter. It contains occasionally rounded pebbles of quartz, and is underlaid with beds of sand and gravel, which, of course, rest at varying depths upon the country rock.

The sandy land, which occupies a narrow strip between the red lands and the river bottom has a growth of short-leaf pine and oaks, with water oak and sweet gum in the flats. The soil is a light loam, mostly sandy, of white, gray, and yellowish colors, and four to six inches deep to a change of color. The subsoil is nearly the same as the soil; if anything, more of a yellowish clay, with admixture of coarse sand. Pebbles are found in the subsoil on slopes and elsewhere in places.

All these varieties are generally easily tilled in dry weather; but in wet

a These terms allude to the varying aspect of the Rotten Limestone as it is disintegrated under the influence of the weather, the blue marl being the unaltered rock, and the joint clay, of chalky appearance, the same Rotton Limestone, broken and partially desiccated.—E. A. S.

weather the prairies especially are often quite difficult. The chief crops are cotton, corn, and oats, the sandy lands being suited to cotton and the prairie lands to corn and oats. From two-thirds to three-fourths of the tillable land of all sorts is devoted to cotton, which is most productive when three or four feet high. Verry little land is turned out. Serious damage is sometimes done to hillsides by washing.

CRENSHAW.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

PIKE.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

BULLOCK.

Population: 29,066.—White, 6,944; colored, 22,122.

Area: 660 square miles.—Woodland, all, except a few square miles of open prairie; Prairie region, 300 square miles (200 of Black prairie, etc., and 109 Hill prairie or Chunnenugga ridge); Oak and Hickory Uplands, with Long-leaf Pine, 360 square miles.

Tilled lands: 176,860 acres.—Area planted in cotton, 80,470 acres; in corn, 47,441 acres; in oats, 6,177 acres; in wheat, 111 acres; in rye, 88 acres; in sugar-cane, 429 acres; in rice, 16 acres; in sweet potatoes, 773 acres.

Cotton production: 22,578 bales; average cotton product per acre, 0.28 bale, 399 pounds seed-cotton, or 133 pounds cotton lint.

Bullock county lies wholly within the Cretaceous region, and both the upper and lower subdivisions of this formation are concerned in the formation of its soils. In addition to this, the beds of the Stratified Drift are spread over all, modifying the soils, and in some cases forming them outright. The limit between the upper and lower divisions of the Cretaceous, running nearly east and west, falls near the center of the county, the precise position of this limit being very difficult to determine, because of the overlying Drift.

Of the two divisions of the Cretaceous represented in this county (Rotten Limestone and Ripley), the former is not found south of the ridge upon which Union Springs is situated (Chunnenugga ridge). Beyond this, to the southern line of the county, the Ripley marls and limestone make

the country. This ridge, which divides the waters flowing into the Tallapoosa river from those of Cowikee creek and Conecuh and Pea rivers, slopes gently away toward the south, but toward the north there is a rather abrupt descent into the prairie lands, which stretch thence northward to the county line. Of the prairies, there is little to be said in a general way more than has already been given under other counties, and the very full reports below will furnish all the needed details.

Chunnenugga ridge has a northeast and southwest direction, and is made up of beds of limestone, marl, clay and sand. *(a)* In the calcareous clays resulting from the disintegration and intermixtures of these beds, small white concretions of lime are abundant, and perhaps characteristic.

From the statistics, it will be seen that this county ranks high in cotton production, and the following abstracts of carefully prepared reports, which relate to all parts of the county, will be read with profit by all who desire to have an acquaintance with the capabilities of the several soil varieties. The farmers, as a rule, sell their cotton as fast as baled, to the merchants at Union Springs, and thence it is shipped by rail to the various markets.

On account of the great variety exhibited in the agricultural features of Bullock county, I have given somewhat in detail the reports of correspondents from the different sections; and since the adjoining counties are in many respects similar, a repetition will not be needed in each case.

The greater part of the cotton crop is produced upon the calcareous lands of the upper part of the county, where the effects of constant (natural) marling are seen. In the brown-loam uplands, and their intermixtures with the sandier materials, we have nothing different, from an agricultural standpoint, from what may be seen in so many parts of the State elsewhere.

a The marl and limestone contain the fossils characteristic of the Ripley group, and have furnished many of the newly-described fossils of this horizon.

ABSTRACT OF THE REPORTS OF W. M. STAKELY AND J. F. CULVER, OF UNION SPRINGS.

(This report relates particularly to the black lime-lands, partly bald prairie and partly timbered, lying north of Chunnenugga ridge, near Union Springs.)

The black lands alternate with the post-oak prairies, presently to be described, in such a way as to make it impossible to give any strict limits between the two. Taken together, they occupy a belt from five to ten miles wide across the country, widening toward the west. The growth on the black uplands, which make about a fifth of the arable lands of Bullock county, consists of post oaks, interspersed with hickory, short-leaf pines, and other trees in small numbers, and an undergrowth of haw bushes, and is indicative of good cotton land. The heavy soil is a clay loam, sticky and prairie-like in places, and of gray to black colors, according to the amount of vegetable matter present; thickness to a change of color, from three to twelve inches. The subsoil is commonly heavier than the surface soil, and consists of tough yellow and tough reddish clays. The sandy soils have sometimes a yellow sand as subsoil. These subsoils frequently have limy concretions, and are underlaid with a blue marl (Rotten Limestone) at ten to twelve feet depth. In wet seasons, this soil is difficult to till, because of its sticky nature; but in dry weather it is easy of tillage, when previously prepared, and, in general, may be classed as an early, warm soil.

Cotton, corn and oats are the principal crops produced, the soil being best suited to the first two, though three-fourths of the cultivated land is in cotton, which grows to a height of from two to five feet, being most productive at about four feet. At present, very little of this kind of land lies turned out, and when it is reclaimed, it produces well the first year and better afterward. There is some slight damage from washings; but the valleys are not much injured by the washings from the uplands, and some efforts have been made by hillside ditching to check it, with moderate success.

ABSTRACT OF REPORT BY J. L. MOULTRIE, OF UNION SPRINGS.

(Relates more particularly to the post-oak lands or timbered prairie lying upon the headwaters of Cupiahatchee creek, a tributary of the Tallapoosa river.)

The prevailing growth is post oak, short-leaf pine, with some hickory, red oak and black-jack on hills; in the bottoms, poplar, elm, gum, ash, shell-bark hickory, and some walnut. The light soils are fine loams; the heavier more clayey; colors, gray red to nearly black. Thickness to change of color, three to six inches; in the bottoms, one to two feet. Subsoil mostly red-joint clay; sometimes a yellow marly clay. On sandy hummocks, the clay is yellow and mixed with mica, and is underlaid with blue or greenish marl; on sandy hummocks, sometimes pebbles, about thirteen feet from the surface, and only about six inches deep. A blue marl underlies the subsoils at a depth of about twenty-five feet. In wet weather, the soil is rather difficult to till, as it becomes sticky, and it is always heavier than the sandy land. The soil is naturally well drained, even in bottoms, and is early and warm. Cotton, corn, oats and sweet potatoes are the chief crops. The thin gray and clay lands are best suited to cotton, the deep black land to corn and oats, and the white bald prairie to corn.

Fully three-fourths of the land is put in cotton. The stalk grows from two to five feet, being most productive at four feet. None of this land lies turned out, except for want of labor to cultivate it, and from this cause, probably one-twentieth is idle. If neglected, this soil is likely to be injured from gullies. The valleys are not hurt unless the washings are clay. Hillside ditching is sometimes practiced with good success.

ABSTRACT OF REPORT OF M. L. STINSON, OF UNION SPRINGS.

(Refers chiefly to the sandy and loamy soils making the bottoms and uplands upon the waters of Conecuh and Pea rivers and their tributaries.)

The soil varieties described are derived from the loams and other drifted materials of the Post-Tertiary formation, and vary in accordance with the varying proportions of sand and clay. The varieties enumerated are: first, loam lands, with growth of short-leaf pine, oaks and hickory; second, loam lands, with black-jack as the characteristic growth; and third, sandy lands, with prevailing timber of long-leaf pine and black-jack oak. The lower part of the county, south of Union Springs, is made up of these lands, the sandy pine lands occupying about half the territory, the other two varieties the balance. The oak uplands have, in addition to the growth above named, chestnut, beech, poplar, elm, magnolia, cottonwood, cucumber, dogwood, maple, walnut, etc. The soil varies from a fine sandy to a stiff prairie-like consistence, where the marls of the Cretaceous are near enough to the surface to be felt; thickness to a change of color, one to six inches. The subsoil, from six to eighteen inches, is a stiff yellow clay or dark yellowish sand, containing occasionally rounded pebbles of quartz. Below the subsoil, clay and sand to the marl, at an average depth of thirty feet. The black-jack land sustains a growth of pine, hickory, black-jack, and post oaks, some chestnut, chincapin, sloe, etc., and has a soil chiefly sandy, two inches deep, with subsoil of yellowish sand, containing pebbles, and from two to eight feet deep. The underlying rock, at depths of forty or fifty feet, is the marl above alluded to. The two soils seem to differ only in the depth from the surface of the clay, and upon its quality.

The third variety of land supports a growth of long-leaf pine and black-jack oak, and needs no further description, as the same quality of land has been frequently the subject of remark, and the pine woods, wherever found, bear approximately the same character.

Agriculturally, the loamy and sandy lands are of easy tillage, and are all warm and well drained. The prairie lands are considerably earlier than any of the sandy lands, and cotton grows much more rapidly on the strong limy lands. The usual crops are produced upon all these lands, the stiffer clayey lands being best suited to cotton, and the sandy to corn and peas. About half the cultivated area of the first two and about a third of the pine land is in cotton. The height of stalk varies greatly, but the higher the better for yield. Not much of the originally cultivated land lies turned out, except for lack of labor to cultivate it. The pine land has not been cleared up much. The better qualities do very well when reclaimed, but the worn pine lands are not considered worth the trouble of reclaiming. The loam

lands, because of their uneven surface, are liable to injury from washing; but the pine lands are mostly level. Hillside ditching is practiced, with very good results.

MACON.

Population: 17,371.—White, 4,587; colored, 12,784.

Area: 630 square miles.—Woodland, all. Gravelly Hills, with Long-Leaf Pine, 330 square miles. Prairie region, 260 square miles; Metamorphic region, 40 square miles.

Tilled land: 133,924 acres.—Area planted in cotton, 56,763 acres; in corn, 23,833 acres; in oats, 6,195 acres; in wheat, 1,916 acres; in rye, 45 acres; in sugar-cane, 140 acres; in sweet potatoes, 928 acres.

Cotton production: 14,580 bales; average cotton product per acre, 0.26 bale, 372 pounds seed-cotton, or 124 pounds cotton lint.

The geological and agricultural features of Macon county are, in great measure, similar to those of its neighbor on the east, Russell. In the extreme northern part of Macon county, the metamorphic or crystalline rocks make the substratum of the country. These are generally covered by the superficial deposits of a much more recent period, and seldom take any prominent part in the production of the soils. The line of contact of these rocks with those of the Cretaceous formation is everywhere hidden by these surface beds, and it is only south of Tuskegee that the Cretaceous strata have been recognized. The black Cretaceous prairie soil does not appear over any considerable area until the southern limit of the county is nearly reached, within seven miles of Chunnenugga ridge. (Tuomey.)

The remarks of Professor Tuomey upon the soils of this part of the county are of sufficient value to be presented at this point again. In speaking of the area formed by the Rotten Limestone, he says: "The surface is undulating and covered with black and yellowish soils. The bald spots are covered with ash-colored soils. The whole of the limestone near the surface is broken up by laminæ and joints, but yet contains fossils in place and numerous concretionary nodules of lime so white as to resemble caustic lime. This stratum is about twenty feet in thickness; this is called by the well-borers 'clay,' and is the limit of the sipe-wells.

The water, percolating through the fissures, furnishes these wells. Under this the Rotten Limestone assumes its usual characteristics. Near Town creek a good opportunity was afforded of seeing the junction of the post oak and ordinary soil of the prairie." At this place Professor Tuomey observes: 1. The fissured rock mentioned above, which is found on all the bald spots. 2. The sudden termination of the preceding stratum as if it were washed away by water. 3. A bed without fossils, which appears to be an accumulation of lime and clay with organic matter, deposited after the removal of a portion of the fissured rock, the subsoil of the post-oak soil."

From these passages it seems that the post-oak soil is the result of the reaction of the limy materials of the Cretaceous beds upon the loams of the overlying and more recent formation, while the ordinary prairie soils are the result of the disintegration of the Rotten Limestone itself. The fact that soils in many respects analagous to the post-oak soils, are to be seen where the calcareous rocks of the Teartiary have, after disintegration,'mingled with the overlying loams, gives additional force to the view advanced by Professor Tuomey.

A short distance east of the town of Tuskegee the beds of Drift are well displayed. These consist of 20 or 25 feet of light-colored micaceous sands with cross bedding, above which are about four feet of reddish sand, and over this ten feet of the white, all capped by the reddish, irregularly stratified beds of sand, clay, and loam of the usual type of the Stratified Drift. Of course, with such thickness of overlying strata, the Cretaceous rocks rarely have much to do with the soils.

In the southeastern corner of the county the sandy ridge with substratum of bluish marl, which is so prominent a feature of Bullock county, occupies a small area. Upon this ridge the soils are sandy and loamy, but beyond it come the peculiar soils of the Cowikee lands, already fully discussed under Russell and Barbour.

The creeks which traverse Macon county have in many instances cut their channels through the surface-covering of Drift, and the soils along the lowlands thus formed fre-

quently differ very considerably from those of the adjacent uplands. Caleebee creek, from its source to its mouth, passes through a rich country with dark soil, derived from the rotten limestone and other Cretaceous rocks. The same may be said of Cupiahatchee creek. The uplands on and near both the streams have mulatto soils with a growth of oaks and hickory. Eufaupee creek for twenty miles from its mouth flows through a country with yellow sandy soil and a stiff yellow clay below, containing usually a good deal of yellow and white quartz pebbles. Big Swamp creek traverses a rich section of the county. The soil is dark and very productive. Chewacla creek passes generally through piny woods, but cuts through the surface beds, and the bottom soils are in places dark blue and very productive. The pine land is poor.

Agriculturally, Macon county enjoys several advantages over its western neighbors on the Pine Hills belt, for in the southern part of the county the underlying calcareous rocks are exposed, and in the eastern the same is true of the blue marl, as it is called. Both these underlying formations exercise a very beneficial influence upon the prevailing sandy loams, which are marled more or less thoroughly by such intermixtures.

ABSTRACT OF THE REPORT OF JOHN L. COLLINS, OF TUSKEGEE.

The soils are the varieties above enumerated. Those of the uplands are generally sandy loams, of yellowish to light colors; those of the bottom vary with the locality, being clay loams, and in places prairie-like. The subsoils, mostly somewhat heavier than the top soils, often consist of yellow or red clay, and in most of the county are underlaid with sand, which often contains pebbles. The soils are easy of tillage, except when wet. The chief crops are cotton, corn, oats, rye, wheat, etc., and the lands are about equally well adapted to each.

Two-thirds of the cultivated land is in cotton, which on good land attains a height of four feet; on poor land, eighteen inches to two feet. Perhaps a third of the land originally cultivated now lies turned out, but when again taken into cultivation it yields about a third less than when fresh. On slopes all this land washes badly, and the injury to the uplands is considerable, but the bottoms are, if anything, benefited thereby. Occasionally efforts have been made to check this by horizontalizing, etc., and with very fair success.

RUSSELL.

Populatiou: 24,837.—White, 6,182; colored, 18,655.

Area: 670 square miles.—Woodland, all. Gravelly Hills with Pine and Oak Uplands with Pine, 370 square miles; Blue-marl lands, 300 square miles.

Tilled land: 134,320 acres.—Area planted in cotton, 81,582 acres; in corn, 34,335 acres; in oats, 9,789 acres; in wheat, 1,099 acres; in rice, 65 acres; in sugar-cane, 196 acres; in sweet potatoes, 1,093 acres.

Cotton production: 19,442 bales; average cotton product per acre, 0.24 bale, 342 pounds seed-cotton, or 114 pounds cotton lint.

Russell county, though underlaid with the strata of the Cretaceous formation, depends for its soils in great measure upon the thick beds of the Stratified Drift, which cover the whole county to a greater or less degree. The great Drift bed which borders the older formations of the State crosses this county from east to west, and covers the northern half. The water-shed between the Tallapoosa and the Chattahoochee, which is the continuation of the Chunnenugga ridge of Bullock county, enters Russell near the middle of its western boundary. Its further course northeastward toward Columbus has not been definitely traced out, but it is probable that it is soon merged into the great pebble belt previously mentioned. Northward of this ridge occasional patches of the black prairies of the Rotten Limestone are met with where the overlying pebbles and sands have been removed by denudation. The prairies, however, are in detached bodies, and do not form large tracts, as is the case to the westward.

Southward and southeastward of the water-shed previously mentioned the beds of marl, etc., of the Ripley group are often exposed by the removal of the Drift deposits, and the reaction of this marl upon the overlying loams gives rise to the peculiar soils of Cowikee creek. Some of the characters of this class of soils have been given under the head of Bullock county, and vary from a stiff clay to rather sandy, the lighter soils being found generally on the north side of the streams. Local patches of a tenacious clayey soil,

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called "hog-wallow prairie," are here and there met with in Cowikee lands. The timber throughout this region is a mixture of long-leaf pine, with hickory, white and Spanish oaks, and sweet and sour gums and maple in the bottom lands. The hog-wallow clay in dry weather packs very much after the fashion of the prairie soil of the Rotten Limestone, but the colors differ, being reddish here, and grayish or grayish-yellow in the Rotten Limestone. The low, heavy lands of the Cowikee alternate with light sandy soils upon the hillsides and divides, and occasionally beds of deep white sand are encountered, which remind one of the pine barrens of the extreme south. The presence of an unusually large proportion of mica in the Drift sands has been mentioned under Bullock county, and the same thing may be noticed in this county also.

A line drawn diagonally through the county from northeast to southwest would approximately separate the Rotten-Limestone lands from those of the Ripley marls. The former are found only in detached bodies among the greatly preponderating loams and sands of the overlying Drift, while the latter are quite characteristic of the region in which they occur.

From what has been said, it will not be difficult to understand the variety and distribution of the soils as they occur in Russell county, being the sandy and loamy soils of the Post-Tertiary deposits on the one hand, and the heavy black-prairie soils of the Rotten Limestone and the stiff, clayey to light sandy and marly soils of the Ripley group on the other. Most of these soil-varieties have already been fully described.

The high rank of Russell county in cotton production is due chiefly to the cultivation of the lands in which the Blue marl, as it is called, forms the substratum. The intermixture of the Blue marl with the overlying loams has the effect of stimulating the latter to its utmost capacity.

The cotton crop is usually sold to the merchants at the various railroad stations in the county, and thence shipped to the various markets north and east.

BARBOUR.

Population: 33,979.—White, 13,091; colored, 20,888.

Area: 860 square miles.—Woodland, all. Oak and Hickory Uplands, with Long-leaf Pine, 610 square miles; Blue marl lands, 250 square miles.

Tilled land: 197,455 acres.—Area planted in cotton, 100,442 acres; in corn, 61,822 acres; in oats, 10,264 acres; in wheat, 131 acres; in rye, 112 acres; in rice, 35 acres; in tobacco, 22 acres; in sugar cane, 647 acres; in sweet potatoes, 1,274 acres.

Cotton production: 26,063 bales; average cotton product per acre, 0.26 bale, 372 pounds seed-cotton, or 124 pounds cotton lint.

A line drawn east and west through Barbour county, near the center, will divide it into two parts which are quite dissimilar. The soils on the north of this line are more or less calcareous, those on the south sandy. The northern half has a substratum of marl and limestone of the Upper Cretaceous formation (Ripley group), which, acting upon the soil, gives rise to some of the best and safest cotton lands in the State. This portion of the county is drained by the three forks of Cowikee creek, and is known throughout the county as the Cowikee lands. The soil is a moderately stiff calcareous clay, with patches of what is known as hog-wallow, which are seldom more than an acre or two in extent. In the immediate vicinity of the streams the soil is much more sandy, but highly productive. The general appearance of these lands is that of a gently undulating, occasionally hilly region, somewhat resembling the prairies of the Rotten-Limestone country, but with reddish or light-colored soils. This region, though fertile, is malarious, and is inhabited by comparatively few white families. The negroes, however, appear to endure it very well. There is a peculiar mixture of trees characterizing these lands, viz: hickory, white and Spanish oaks, sweet and sour gums, and long-leaf pine. The latter appears out of place with such surroundings.

Upon the divides in the Cowikee region the strata of the Post-Tertiary are found, consisting of sands, clays, and peb-

bles, with the usual irregular stratification. These beds throughout the county show a larger proportion of mica than is usually seen; a fact which may possibly find an explanation in the nearness of the Metamorphic area of the State. The soils produced by these surface beds are of the same general nature with similar soils in other parts of the State, varying from the extremes of sandy to clayey, and supporting a correspondingly varied growth—long-leaf pines upon the sandier and the various species of oaks upon the more loamy portions.

The southern half of the county is underlaid generally with the beds of the Tertiary formation, but these are seldom concerned in the formation of the soils, since they are covered with the sands and loams of the Stratified Drift. Upon occasions the Tertiary beds approach the surface and bring about modifications of the soil. Taken as a whole, however, the soils of the southern half of Barbour are deficient in lime and generally sandy, and the country high and rolling, with good freestone water attainable by wells from 20 to 30 feet deep. This land is not specially suited to cotton, though the free use of fertilizers will always produce a satisfactory yield. In places where the overlying drifted materials have been partially removed the calcareous and greensand beds of the Tertiary give rise to the formation of local tracts of very fine soil, similar in all respects to those mentioned under Pike county.

The Chattahoochee river forms the eastern boundary of the county, and the bottom lands of this stream are from one to three miles wide, and very productive. Next to these are the second bottoms or hummocks, or pine flats, always safe and easy to cultivate. Bordering upon these are the foot-hills of the pine uplands.

Although the larger part of the surface of this county is occupied by brown loams, with a growth of oak, hickory, and pine; yet the characteristic agricultural features of Barbour depend upon the Blue marls of the Cowikee and other drainage areas of the northern half of the county. A large proportion (more than half) of the cotton crop is produced in the northeastern part of the county, where these marls give character to the soils. There is, perhaps, no part of the

State which ranks higher in the production of cotton than the Blue-marl lands of adjacent parts of Russell, Barbour, and Bullock counties, whose prevailing soils are light sandy loams, easily worked, possessing a comparatively high percentage of lime, by which they are rendered extraordinarily thrifty.

ABSTRACT OF THE REPORTS OF JUDGE H. D. CLAYTON, OF CLAYTON, AND DR. H. HAWKINS, OF HAWKINSVILLE.

(The region reported upon lies at the headwaters of Choctawhatchie river, and includes both uplands and lowlands; also, the Cowikee lands are described.)

No local causes influence the growth of cotton in the former region, but in the Cowikee lands the heavy dews are thought to be favorable to the growth. The upland soils are gray to red in color, and mostly sandy and porous. The gray lands are about three-fourths and the red about one-fourth of the area. The growth upon the gray land is a mixture of long-leaf pine, red, white, and post oaks, and hickory, and that on the red land the same, with the addition of walnut, persimmon, grape-vines, chincapin, buckeye, etc. The red soil is usually much stiffer than the gray, and has a subsoil of sometimes very hard clay and sand, underlaid frequently with a hard-pan at a depth of several feet.

These soils are easy of tillage at all times, and produce the usual crops, being, however, best adapted to grain, potatoes, and peas, although cotton forms at least half of the cultivated crops. The most productive height of stalk is about three feet. About a fourth of this kind of land lies turned out, chiefly because since the war the negro laborers cannot be induced to care for the land and keep the ditches cleared out either on hillsides or in the bottoms unless especially hired for the purpose, and this takes too much money from the owner of the land to justify him in so doing. On some farms, where the negroes have become attached to the place, they can, by a little coaxing, be induced to keep up the land.

When turned out for 10 or 15 years and grown up in old field, pine lands will produce nearly as well as the fresh lands when reclaimed. A great deal of injury is done both to the hills and the valleys by washings and gullies. When the hillsides are turned out and grow up in the pines, the valleys are improved, there being no washings from above.

The soil of the Cowikee lands is a fine sandy loam, alternating with a heavier, clayey, sometimes prairie-like loam, both more or less strong in lime. The color is usually gray or yellowish, and the subsoil is also of light color. The common growth is oak, hickory, and long leaf pine. The three branches of Cowikee creek flow together before reaching the river. On the north side of each the land is comparatively level, and the principal growth pine; the soil, light-gray, chincapin, and hog-wallow. On these the cotton is small but very prolific, though most subject to rust after the land has been cultivated for a few years. On the south side of these streams the land is much stronger, with more lime, and produces a large cotton weed; it is also better for corn.

In wet seasons the land is rather difficult to till, but yields fine crops. Cotton occupies four-fifths of the cultivated land, and the height of stalk at which it is most prolific is from three to four feet. About 10 per cent. of the land lies out, but it does well when reclaimed. The soil washes badly on slopes, and the valleys are injured, often to the extent of 10 per cent., by the washings from the uplands. Some slight efforts have been made to check the damage by horizontalizing, hillside ditching, etc., and with good success.

THE FLATWOODS BELT.

This comprises a narrow strip running through the counties of Sumter,* Marengo,* and Wilcox.*

SUMTER.

(See "Central Prarie region.")

MARENGO.

(See "Central Prairie region.")

WILCOX.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

OAK AND HICKORY UPLANDS, WITH LONG-LEAF PINE.

This region comprises wholly, or in part, the following counties: Sumter,* Choctaw, Clarke, Monroe, Wilcox, Butler, Conecuh, Covington,* Crenshaw, Montgomery,* Bullock,* Barbour,* Pike, Coffee, Dale, and Henry.

SUMTER.

(See "Central Prairie region.")

CHOCTAW.

Population: 15,731.—White, 7,390; colored, 8,341.

Area: 930 square miles.—Oak and Hickory and Long-leaf Pine Uplands, 830 square miles; Lime Hills, 100 square miles. Of the former, 475 square miles are long-leaf pine uplands and 355 square miles brown-loam uplands.

Tilled land: 77,182 acres.—Area planted in cotton, 31,086 acres; in corn, 25,613 acres; in oats, 3,338 acres; in rice, 38 acres; in sugar-cane, 101 acres; in tobacco, 23 acres; in sweet potatoes, 748 acres.

Cotton production: 9,054 bales; average cotton product per acre, 0.29 bale, 414 pounds seed-cotton, or 138 pounds cotton lint.

In Choctaw county the rocky substratum is made by the various beds of the Tertiary formation, and while these underlying older rocks have been covered with deposits of sand, pebbles, and loam of a later period, yet they are in many places sufficiently near the surface to modify the soils, and in some instances to form them outright. On account of the slight southward dip of the Tertiary beds, we find the lowest and oldest of these in the northern part of the county, while the latter beds appear at the surface in succession as we go southward.

Throughout the county the higher levels of the table-lands have the brown loam to gray sandy soils of the Drift deposits before named; but where these have been removed, as upon the slopes and on the borders of the lowlands, then the Tertiary rocks come to light and produce many decided soil varieties. The lowest Tertiary beds occurring in Choctaw county consist of laminated clays, usually of grayish colors, which are interstratified with sandy strata containing great numbers of marine shells, constituting marl beds. These beds occur as far south as the latitude of Butler, and, where they take part in the formation of the soils, give rise to heavy clayey soils on the one hand and to stiff calcareous loams on the other. About Butler may be seen lime-hills of this character. The growth on these hills consists chiefly of post oak, hickory, and short-leaf pine, with a few oaks of other species. Most of these trees are draped with long moss. Where the overlying sandy loams are thick the long-leaf pine becomes abundant, and on most of the sandy plateau it is the prevailing tree.

The next division of the Tertiary, which makes its appearance south of Butler in a belt extending to Bladon Springs, is made up of aluminous sandstones and claystones, which overlie beds of dark-colored clays, interstratified with

beds of greensand marl. Where the sandstones are prominent the topography is quite varied and consists of high, steep hills, with deep, narrow ravines. The soils which depend upon this material are naturally poor, and the timber is mostly of long-leaf pine, black-jack, and high-ground willow oaks; but the calcareous deposits previously mentioned give rise to very good limy soils, where sufficiently large tracts of land level enough for cultivation can be found. In all this section between Butler and Bladon Springs, the creek bottoms appear to be very productive and to contain a considerable proportion of lime, as may be inferred from the luxuriance of the vegetation and the prevalence of the spruce pine, which seems to be a lime-loving tree. The uplands between these streams have the usual sandy loam soils, and in some places the sandstones themselves form the soils, which are then almost worthless for cultivation.

South of Bladon Springs (the waters of which, like those of Tallahatta Springs, on the other side of the river, come from the Tertiary rocks just described) the country is formed of the strata of the Jackson and Vicksburg groups of the Tertiary, and are either calcareous clays, marine shell deposits, or white limestone. In places, particularly along the usually very steep slopes bordering the streams, the calcareous beds, and especially those of slight coherence, mingle with the materials of the overlying deposits, and produce the peculiar soils of the Lime-hills. These vary from a stiff, limy red loam to a black soil very much like some of the soils of the Central Prairie belt. Unlike these, however, the Lime Hill soils appear in this county only in comparatively limited patches, and the region of their occurrence has the prevailing characters of the pine uplands, the calcareous soils forming only a small proportion of the total area.

From Mr. James Hamrick, of Isney, I learn that the belt of what is called in this county "shell prairie" is about five miles wide, and enters the county in township eleven, range five, west, and passes southeast, leaving the county in township nine, range three, west. These and the creek bottoms form the very best lands in the county.

All the divides and high lands of the southern part of the

county have rather thick beds of Drift and Loam overlying the Tertiary, and the agricultural features are hence mostly independent of the latter, except along the drainage slopes.

It will be seen from what has been said that while the prevailing character of Choctaw county is that of the Long-leaf Pine Uplands with Oak and Hickory, yet the most productive lands, and those which are of most importance to the cotton-planter, are the shell prairie and creek bottoms. In the adjoining counties of Clarke and Wayne, in Mississippi, the shell prairies are of the same nature, though, if anything, rather more widely distributed, and in larger bodies.

The Tombigbee river on one side of the county, and the Mobile and Ohio railroad, in Mississippi, on the other, furnish the only means of transportation for the products of the distant markets.

CLARKE.

Population: 17,806.—White, 7,718; colored, 10,088.

Area: 1,160 square miles.—Woodland, all. Lime-hills, 560 square miles; Oak and Hickory and Long-leaf Pine Uplands, 340 square miles, of which 100 are Brown-loam Uplands and 240 Long-leaf Pine Uplands; Rolling and Open Pine Woods, 260 square miles.

Tilled land: 77,186 acres.—Area planted in cotton, 33,477 acres; in corn, 28,220 acres; in oats, 5,065 acres; in tobacco, 19 acres; in sugar-cane, 200 acres; in rice, 22 acres; in sweet potatoes, 1,256 acres.

Cotton production: 11,097 bales; average cotton product per acre, 0.33 bale, 471 pounds seed-cotton, or 157 pounds cotton lint.

The position of Clarke county, in the angle of the Alabama and the Tombigbee rivers, is favorable to the production of a diversified topography and to the exposure of its rock structure; hence the study of its natural features is of the greatest interest. The Tombigbee receives by far the greater part of its surface drainage, for the divide between the two rivers runs within ten miles of the Alabama river the whole length of the county. It thus follows that its principal

creeks—Bashi, Tallahatta, Satilpa, Jackson's, and Bassett's—flow west or southwest diagonally across the county. The rock strata have a gentle dip southward, and to this relation between the directions of the streams and the dip of the rocks is due one of the striking topographical features of the county, viz: that escarpments or abrupt hills are found on the southern or southeastern borders of these streams, while to the north and northwest the slopes are very gradual, often almost imperceptible.

The Tertiary strata which form the substratum of Clarke county have been covered with beds of sand, pebbles, and red loam, and the altitude of the main water-sheds, which are, in general, plateaus covered with these drifted materials, is about 500 feet above tide. The greater part of the original surface has been irregularly worn away by erosion, and especially is this the case in the lower part of the county, where the two rivers are not more than from six to ten miles apart. Both the Tertiary strata and the Drift beds overlying them have contributed to the formation of the soils of the county, but in very unequal proportions, since the Drift occupies the greater part of the surface.

The high hills which overlook and form the southern border of the drainage area of Tallahatta creek are caused by hard sandstones and claystones perhaps 200 feet in thickness. These rest upon dark-colored laminated clays and sands, which form their lower parts, and underlie also the whole region north of them to the line of Marengo and beyond. The Tallahatta hills, as they may be called, are rough and rocky, and have in general poor, sandy soils, upon which long-leaf pine and black-jack and high-ground willow oaks form the principal timber. Where the streams have cut down through these sandstones into the underlying strata the soils are often of much better character, for reasons which will appear hereafter. Usually in the region of these hills there are no good soils, and the country is very sparsely settled. Cattle, however, find very good pastures.

North of the Tallahatta hills the lignitic clays and sands form a much more level country, whose soils, while in a great measure derived from the overlying Drift beds, are nevertheless in places greatly modified by intermixtures

with these older rocks. Interstratified with the clays and sands are one or two beds of shell marl containing a notable amount of greensand, and where these come to the surface a great improvement in the soil may be noticed. This improvement is most strikingly seen in the Lime Hills, a belt of which crosses the county nearly east and west through Choctaw Corner. The limy tracts are not always continuous for long distances, but are rather in detached bodies, except eastward near the Wilcox line, where they become characteristic. The hills are usually very steep, and the soil, in consequence, washes badly, and when left out of cultivation soon becomes disfigured by unsightly gullies. The timber is chiefly beech, but with it are many other trees, such as hickory, white oak, sweet gum, short-leaf pine, spruce pine, etc.

Southward from the Tallahatta hills, (leaving out of account the superficial Drift beds) the whole county is formed of beds of white limestone of varying degrees of purity, which are interstratified with thinner beds of loose shell marl. These rocks and marl beds, with one principal exception, do not play any very important part in the formation of the soils. This exception is found in the lowermost of the limestone beds, which is impure and clayey, and in places is almost a calcareous clay. Wherever this rock occurs as the surface formation, or where the surface materials are affected by it, it gives rise to a series of peculiar soils which characterize the lime-hills and shell prairies. The varieties of soil depending on this rock alone are of two kinds: a loose, black material, and a gray, waxy clay, which becomes black on the addition of vegetable matter. A mixture of this gray clay with the red-drift loam produces a stiff yellowish or mahogany soil, difficult of cultivation, but very fertile. These soils and their characteristic vegetation have been somewhat fully described in the general part (page 280).

It would be a mistake to suppose that the prairie or lime soils form the majority of the tillable lands, even where they give character to the country. The great proportion of all the soils is derived from the surface loam previously spoken of, and the limy soils are seen usually in small de-

tached bodies, mostly at lower levels, where the superficial beds have been removed by denudation. This limestone is the matrix of the huge bones (of *Zeuglodon*) which have been found from time to time in Clarke county. Associated with it are also beds of gypsum, which is found occasionally in crystallized form in great quantities imbedded in clay. This gypsum might be profitably employed upon the lands of the sections where it abounds. The lime-hills occur from the latitude of Coffeeville and southward as far as the vicinity of Barlow Bend, or over three-fourths of the county. In many places the bare white rock is exposed in great bodies, as about Clarkesville, Suggsville, Cedar creek, etc.

The other limestone beds which overlie the one just described play an important part in the topography, but are not so generally concerned in production of a peculiar soil as is the former. It is seen in a great bluff at old Saint Stephens. Portions of it, when freshly quarried, are quite soft, and are easily cut into blocks, which are used in the construction of chimneys. The thin beds of shell marl which are associated with these rocks have a local effect upon the soils. Some of them could be profitably employed on the lands which lie contiguous, but they are not generally rich enough to be shipped to distant points. An exception might be made in the case of the marl bed which occurs at the Claiborne landing, in Monroe county, and which is seen at several points on the Clarke county side. This is a shell marl, which in places contains very little else than shells, and might pay to ship.* Some of the more level areas, where the limestone lies beneath the surface, are marked with shallow depressions, or lime-sinks; but this feature is not a common one in Clarke.

Of the soils produced by the surface beds of the Drift it does not seem necessary to speak at this place, since they have been fully treated of in the general part of this report. All the table-lands and many other areas in Clarke have the loam soils, many of which are of excellent quality. The pebbles which so commonly underlie the surface loams usually make their appearance along the hillsides, where

*See, in this connection, the chapter on Fertilizers above.

the table-lands break off toward the water-courses. They may be seen, for instance, about the towns of Jackson and Grove Hill, and in many similar positions.

On the water-shed between Bassett's creek and the Alabama river, there are places where the gullies have encroached on each side upon the hills until only a narrow ridge now remains of the dividing plateau. From this ridge the view is unobstructed on each side, and embraces the whole width of the drainage areas of the two streams.

With reference to its prevailing timber growth, this county may be divided into several distinct belts. The northern belt is a region of oak uplands, with long and short-leaf pine. Interspersed with these uplands are the lime-hills, with beech timber and the peculiar growth which generally characterize bottom lands. South of this come the Tallahatta hills, occupying a belt 10 miles in width, timbered with long-leaf pine and black-jack; thence southward, to the lower limit of the county, are alternations of oak and hickory uplands and long-leaf pine forests, the latter increasing in extent in the same proportion that the former decrease, till below Grove Hill the country has the characters of the pine uplands and rolling pine lands. Within this region are the lime-hills and shell prairies of the white limestone.

The cotton lands of Clarke county are the second bottoms or hummocks of the two rivers, and are often several miles in width, with sandy loam soils, in many cases strengthened by the washings from the calcareous uplands. The creek lands are not so generally desirable, for on the north side the soils are nearly always too sandy. On the southern side, where, by reason of the marly beds, the soils are often of a very superior character, the surface is usually very broken, and it is possible to cultivate only small patches; such, at least, is the case with the principal streams. The small creeks which flow into the Alabama river have generally very little bottom lands, and often steep, rocky banks. The lime-hills, both north and south of the Tallahatta hills, produce fine crops, especially the loose, black-shell prairie of the latter. The upland soils of the red loam have the same character in this county as elsewhere, and are some of

the best and safest of the cotton lands. Clarke county depends upon the two rivers for shipping its cotton to market, and the most of it goes naturally to Mobile. The freight to that point is from $1.25 to $1.50 per bale.

MONROE.

Population: 17,091.—White, 7,780; colored, 9,311.

Area: 1,030 square miles.—Woodland, all. Undulating pine lands, 380 square miles; Pine Uplands, 250 square miles; Brown loam or Oak and Hickory Uplands, 130 square miles; Lime-hills, 270 square miles.

Tilled land: 77,317 acres.—Area planted in cotton, 33,463 acres; in corn, 24,135 acres; in oats, 4,597 acres; in rice, 78 acres; in sugar-cane, 329 acres; in tobacco, 11 acres; in sweet potatoes, 920 acres.

Cotton production: 10,421 bales; average cotton product per acre, 0.31 bale, 441 pounds seed-cotton, or 147 pounds cotton lint.

In its geological structure Monroe county closely resembles Clarke, which adjoins it on the west. The underlying rocks throughout the county are those of the Tertiary formation, the aluminous and siliceous sandstones of the Buhrstone group occurring in the northern part of the county, while the white limestone underlies all the southern part. But the beds of sand, pebbles, and loam belonging to the Stratified Drift formation are spread over all these older rocks, and are concerned in the formation of the greater part of the soils.

The sandstones above mentioned form a hilly and much broken country, with poor sandy soils, on the uplands; but as the sandstones are underlaid with a dark-colored laminated clay, interstratified with beds of greensand marl, the valleys lying at the foot of these hills are often very productive. The whole of this region is characterized by rough, precipitous hills with long-leaf pine growth, alternating with fertile limy valleys. Notwithstanding the broken character of the country, some of the most prosperous farmers are located in this section.

In the central and southern parts of the county the to-

pography is comparatively little influenced by the underlying rocks, and the uplands have the prevailing characters of the pine hills or rolling pine lands, and similarly with the soils, which are for the most part the sandy loams derived from the Drift, present no peculiarities. Where, however, these surface materials have been partially removed, as within the drainage areas of Flat and Limestone creeks, the case is different; for, the marls or limestones of the Tertiary formation are uncovered and brought in contact with the overlying loams, and thus are produced those fertile soils of the lime-hills and creek bottoms for which these localities are noted. The uplands bordering these creek lands are the usual sandy pine hills, and as these break off toward the creeks the lime-hills occur, which are usually very steep, and have comparatively little level land on top. The soils are of various colors, from gray and reddish to nearly black, usually pretty stiff, and sometimes contain shells. The bottom lands, adjacent to the lime-hills, are more sandy, but are usually more or less influenced by the lime of the hills, and make the best cotton lands in the county.

Below the latitude of Monroeville the county is a level or gently rolling piny woods, with occasional lime-sinks, which reveal the presence of the limestone beneath, but this rock seldom appears at the surface except along the banks of the streams. In all this region very little cotton is planted except in the lowlands adjacent to the Alabama river.

The cotton lands of Monroe county are the lowlands of Flat and Limestone creeks and the Alabama river. The uplands are generally sandy and not very productive, especially in the southern half of the county. There are some good bodies of table-land with brown-loam soil and red-clay subsoil, but these are similar to the brown-loam soils of the other counties. The marls from Flat creek, where they occur in large enough beds, might be used with advantage on the poorer upland soils, which are within convenient distance.

The agricultural characters of the Flat Creek region are shown in the following abstract:

ABSTRACT OF THE REPORT OF DR. J. M. HARRINGTON, OF NEWTON ACADEMY.

The lowlands of the region described are the first and second bottoms of Flat creek, a tributary of the Alabama river; the uplands are the rolling or level table-lands bordering upon the same. In the lowlands the cotton is generally later than on the surrounding uplands, on account of the cold nature of the soil in the former.

The soils described are: First, the stiff creek bottoms with adjoining sandy lands; second, the rolling lime-hills and their adjoining bottom lands; and third, the sandy uplands.

In the region under consideration about one-half of the cultivated lands are of the first kind, or creek lands. The prevailing timber is poplar, white oak, ash, beech, and sweet gum. The light soils are fine to coarse sandy, and the heavier, clayey loams, sometimes quite stiff. The colors are varied, ranging from whitish to gray, brown, blackish, and black. A change of color to that of the subsoil is usually noticed at a depth of six inches. The subsoil is generally yellow or red, though sometimes it is of a bluish pipe-clay color, and when of the nature of a pipe-clay it is sometimes almost impervious to water. The underlying material is sand, gravel, or limestone, according to the locality. In tilling qualities the soil is difficult both in wet and in dry seasons, and is late, cold, and generally ill-drained. The crops produced upon it are corn, cotton, sweet potatoes, pease, oats, and rice. The soil is apparently best adapted to cotton, which makes about two-thirds of the cultivated crops. The lime lands occupy about one-fourth of the described area, and their natural growth is post oak, hickory, and maple. The soil is usually a heavy clay loam of a whitish, gray, buff, brown, or mahogany color, with an average thickness to color change of three or four inches. The subsoil is generally heavier, and is underlaid with rock from one to four feet in depth. The soil is difficult of tillage in all seasons, but is early and warm, and is better suited to corn than to the other crops. Cotton makes only about one-fourth of the crop planted.

The sandy uplands form about one-fourth of the region herein embraced. The natural timber is long-leaf pine and black and red oaks. It is uniformly a fine sandy loam of whitish, gray, and other light colors, with a thickness of two to four inches down to the change of color. The subsoil is usually heavier, and contains sometimes rounded or water-worn pebbles of quartz, and is underlaid with sand or gravel. This soil is easily tilled under all circumstances, and is early, warm, and well-drained: is best adapted to corn, the cotton forming only one-fourth of the crops. The height of stalk varies from two to three feet on the pine lands to five or six on the lime lands, and in the bottoms, the most productive height being the medium.

The fresh pine lands will yield from 400 to 700 pounds of seed-cotton to the acre; the lime-hills and bottoms, from 1,000 to 1,200 pounds. From one-third to one-fourth of the pine and bottom lands have been turned out, and at least two-thirds of the lime hills; and the latter is hardly ever reclaimed, because it washes so badly that it is about ruined before it is turned out. The other lands, when reclaimed, produce better than when turned out, but not so well as when new. Very little effort has been made to prevent washes.

WILCOX.

Population: 31,828.—White, 6,711; colored, 25,117.

Area: 960 square miles.—Woodland, all. Oak and Hickory Uplands, with Long-leaf Pine, 600 square miles; Central Prairie region, 300 square miles (of which 200 square miles are of the Hills Prairie character and 100 of the Rotten Limestone); Flatwoods, 60 square miles.

Tilled land: 161,228 acres.—Area planted in cotton, 77,076 acres; in corn, 40,053 acres; in oats, 7,011 acres; in sugar-cane, 251 acres; in rice, 14 acres; in tobacco, 15 acres; in sweet potatoes, 1,597 acres.

Cotton production: 26,745 bales; average cotton product per acre, 0.35 bale, 498 pounds seed-cotton, or 166 pounds cotton lint.

Wilcox county has for its underlying rocks the strata of the lowest or lignitic subdivision of the Tertiary formation, except along the northern edge on the eastern side of the river and the northwestern corner, west of the river, where the Cretaceous rocks are found. Where the calcareous beds mingle with the overlying strata of sand and loam a stiff, sticky soil of considerable fertility is produced, the growth on which is a mixture of short-leaf pines, post oaks, etc.

In the direction of Portland the uplands are covered with the strata of the Drift, but as a descent is made toward Pine Barren creek the hard limestones and other calcareous Cretaceous rocks are encountered, and heavy, tenacious clays make the soil. Of the quality of these clays one can best judge after passing over them with a vehicle after rains, when the mud in certain stages of drying sticks to the wheels with a tenacity that is wonderful; it is difficult even to cut it off with a knife. A belt of country similar to this is passed between Dayton and Linden, in Marengo county, as there described.

The belt of Flatwoods which, in Marengo county, has been mentioned as occurring immediately south of the sandy ridge of Linden, is seen in this county also in a similar position. The underlying rocks of the Flatwoods are the laminated clays that lie at the base of the Tertiary forma-

tion. These flatwoods, in Wilcox, are known only on the western side of the river, southwest of Prairie Bluff.

In the lower part of the county the other Tertiary beds come to the surface. These consist of gray and dark colored clays and sands, with which is associated a marl bed containing the mineral greensand.* As a consequence, whenever these calcareous beds are near enough to effect the soil a very marked improvement is observed. The lime-hills which characterize that part of the county west of the river and above Lower Peach Tree owe their existence to these beds. The surface in this region is very broken, and the lands suffer from washes; the soils are stiff, clayey, calcareous loams of gray, reddish, and darker colors, and the timber is mostly beech, with white oak, holly, hickory, ash, poplar, short-leaf and spruce pine. This lime-hill region is bounded on the south by a line of rocky hills, which are capped with sand and clay stones and timbered with long-leaf pine and black-jack oak; but these hills in most cases lie south of the county-line, in Clarke and Monroe. The characters of all these Tertiary strata and of the country formed of them have been described in some detail under Choctaw county, and need not be here repeated.

The river hummock or second-bottom soils of Wilcox county are probably fairly well represented by an analysis of soil from five miles east of Lower Peach Tree (see page 263). The uplands of Wilcox are, therefore, mostly the sandy loams of the Stratified Drift and Loam, and many of the lowlands, not bottom lands, are rendered highly fertile by the calcareous materials of the Lower Cretaceous and Upper Tertiary formations.

The drainage is altogether by means of numerous tributaries into the Alabama river, and the surface in general is broken, with a good deal of level bottom land in the large bends and in the Flatwoods and Prairies of the northwest.

A large proportion of the cotton crop of Wilcox county is produced in numerous bends of the Alabama river. Perhaps the largest of these is Black's Bend, in the southwestern part of the county, long celebrated for the great

* For further particulars concerning these marl beds, the reader is referred to the chapter on Fertilizers above.

quantity of cotton annually produced there. The river has almost everywhere fine first and second-bottom lands. The limy soils in the northeastern part of the county also bring fine cotton crops.

ABSTRACT OF THE REPORT OF HENRY C. BROWN, OF CAMDEN.

(The region described embraces the first and second bottoms of Pursley creek, a tributary of the Alabama river, and the hilly, partly limy, partly sandy uplands of the same drainage area.)

On the lowlands, when the spring season is wet, planting is late, and the cotton does not fully mature before it is seriously damaged by the caterpillar. The uplands, on the other hand, are earlier and more easily worked, but the yield is less than in the bottoms. When the caterpillar is late in coming the yield in the bottoms will double that in the uplands. The soils described are: 1, the stiff clayey and limy lands of Pursely creek; 2, the stiff clay lands with gravel, lying upon slopes, in patches of 15 to 20 acres; and 3, the sandy uplands with red-clay subsoil.

The bottom lands are about a fourth of the cultivated lands of the vicinity, and have a growth of white oak, hickory, elm, ash, beech, magnolia, sycamore, mulberry, and walnut. The soil varies from a light sandy to a heavy clay or often prairie-like loam, with gray to nearly black color. The average thickness to a change of color is six inches, and the subsoil is generally of a heavier nature. The soil will sometimes bake very hard after a rain and in hot sunshine, but by proper cultivation will yield a loose soft material. The subsoil often contains limy pebbles, and it is underlaid with a marl or soft limestone at varying depths. In dry seasons the soil is easy of tillage, but in wet seasons it is very sticky. It is early and warm when well drained, and produces well all the usual crops, being best adapted to cotton, sugar-cane, and rice.

The uplands, or hummocks, form about a third of the area in the region described, and their natural growth is pine, mulberry, black-jack, etc. The soil has the usual characters of the yellow loam, and rests upon beds of sand and gravel, with clay below in many cases. It is easy of tillage under all circumstances, and is early and warm and usually well-drained. The soil is apparently best adapted to oats, pease, potatoes, and corn, only about a fourth of the area being put in cotton.

The third variety of soil is that of the sandy lands, which have a growth of long-leaf pine, and which are the typical piny woods. The soil is of a whitish to gray color, with sandy subsoil, sometimes containing pebbles. Only the poorer classes cultivate this land, which, with proper manuring, may be made to yield a support. It is best suited to sugar-cane, tobacco, rice, etc., and only about a third of the crop is cotton. The height of the cotton-stalk upon these soil varieties varies from one to five feet, according to quality and to the amount of manure used.

Very little of the best land is abandoned, but probably a third of the poorer qualities are not now under cultivation. They all improve by resting; but the piny woods are hardly thought to be worth the trouble of reclaiming after having once been turned out. There is a good deal of injury

from washes, and very little effort has been made to check it. The valleys are sometimes ruined by the sands washed down upon them.

ABSTRACT OF THE REPORT OF FELIX TAIT, OF CAMDEN.

The lands reported lie along the Alabama river. The lowlands are the first and second bottoms of the Alabama river and the cypress swamps, which, when well drained, make the richest farming lands. The uplands are one-fifth limy, the rest sandy, and the pine woods have a very light soil. There are, so far as known, no local causes which influence the growth of the cotton-plant. The only soil described is the sandy soil, which constitutes four-fifths of the land. Upon this land the timber consists of the various species of pine and oak, with hickory, ash, elm, poplar, cedar, etc., according to the position and quality of the soil. In its physical properties it embraces many variations, from heavy to light sandy loams. The subsoil on the red lands and prairies is heavier than the soil, but on the gray or yellow pine lands it is lighter, and white rounded pebbles of quartz are by no means uncommon throughout. The soil is usually of easy tillage, except where there is much lime or clay present. Corn, cotton, oats, potatoes, and pease are the chief crops, but the soil seems best adapted to corn and cotton.

About a third of the area is in cotton, which grows to a height of two to four feet, the largest stalks being the most productive. About an eighth of the land lies turned out. Some qualities are improved by resting; others apparently very little, if at all. The soil washes badly, and much injury is often experienced from this cause; but the valleys are not as a general thing much hurt, and only insignificant efforts have been made to stop the washings.

BUTLER.

Population: 19,649.—White, 10,684; colored, 8,965.

Area: 800 square miles.—Woodland, all. Oak and Hickory or Brown-loam Uplands, 330 square miles; Pine Uplands, 400 square miles; Hill-prairie region, 30 square miles; Lime-hills, 20 square miles.

Tilled land: 87,010 acres.—Area planted in cotton, 35,851 acres; in corn, 24,648 acres; in oats, 7,494 acres; in sugar-cane, 338 acres; in rice, 17 acres; in sweet potatoes, 679 acres.

Cotton production: 11,895 bales; average cotton product per acre, 0.33 bale, 471 pounds seed-cotton, or 157 pounds cotton lint.

The underlying rocks of Butler county, except a narrow strip in the northern part of the county, which is underlaid with the Cretaceous rocks, belonging to the Tertiary formation. As is the case in all the southern part of the State,

this substratum of the older rocks is covered more or less completely with beds of Drift, consisting of sand, occasional pebbles, and, uppermost of all, a red or brown loam, which is concerned in the formation of far the greater part at least of the upland soils. It is only at the lower levels that these underlying rocks are sufficiently near the surface to exercise any influence upon the soils, with the exception of the aluminous sandstones of the Buhr-stone group, which crop out in some of the highest and most rugged hills in the lower part of the county. These sandstones give rise to very poor sandy soils, on which prevails a growth of long-leaf pine; but underneath the sandstones are gray clays with thin beds of a calcareous nature, often containing the mineral greensand; so that even in this hilly and generally poor country the slopes and creek bottoms are quite productive from the washings from these limy beds.

Below Greenville the county is generally of the pine-hills character, especially the uplands. Around Greenville there is a considerable area of red lands (often containing pebbles and fragments of brown iron ore in quantity), timbered with Spanish and post oaks, hickory, and short-leaf pine, sweet and sour gum, and some chestnut and chincapin. The top soil is a brown loam, passing into the deep-red loam at a few inches depth. In favorable seasons this land will yield, when fresh, 1,000 pounds of seed-cotton or from 25 to 30 bushels of corn to the acre.

In the northern part of the county the beds of the Cretaceous formation are encountered, and they give rise to several very characteristic soil varieties. The rocks of this formation in Butler county are hard limestones of yellowish color, interbedded with softer materials, which are easily removed by the action of the weather. The limestones thus undermined break off in ledges, which crop out along the slopes of numerous very steep limy hills. The soils of these hills are stiff calcareous clays, which, by intermixture with the overlying loams, produce a number of soil varieties. Within this area are small detached bodies of somewhat level land, timbered with post oaks chiefly, to which the name of post-oak-beeswax prairies has been applied. Other lands of a flatwoods character exist which are tim-

bered chiefly with pines, and these are called beeswax-pine lands, but none of them are of the same character or origin as the post-oak flatwoods of Sumter and Marengo counties, which are based upon a Lower Tertiary clay. In the northwestern corner of the county there is a small area of prairie land noted for its productiveness and fine cedar timber. This is of the same kind as the calcareous lands of that part of Wilcox county which immediately adjoins it.

In its agricultural features Butler is similar to the adjoining counties. In the lower part of the county the pine lands are generally cultivated with the use of commercial fertilizers, and the red-loam subsoil of most of these lands is well calculated to retain the manures.

The Mobile and Montgomery railroad traverses this county, and affords a means of transportation to market for the products of the county. Planters usually sell their cotton crop to the merchants at the nearest railroad station, and, for some parts of the county, it is sent to Troy, in Pike county.

CONECUH.

Population: 12,605.—White, 6,224; colored, 6,381.

Area: 840 square miles.—Woodland, all. Lime-hills and Red Lime-lands, 470 square miles; Pine Uplands, 120 square miles; Rolling Pine lands, 250 square miles.

Tilled land: 46,965 acres.—Area planted in cotton, 16,523 acres; in corn, 20,118 acres; in oats, 3,173 acres; in rye, 32 acres; in sugar-cane, 267 acres; in rice, 121 acres; in sweet potatoes, 652 acres.

Cotton production: 4,633 bales; average cotton product per acre, 0.28 bale, 399 pounds seed-cotton, or 133 pounds cotton lint.

The rocky substratum of Conecuh county is made by beds of the Tertiary formation, and over all is spread a mantle of irregularly stratified sands, clays, pebbles, and loams, constituting the Southern or Stratified Drift. The beds of the Buhr-stone group underlie the northern part of the county, and the white limestone of the Vicksburg age makes its appearance in the southern part, whence to the Florida line it is the country rock. The Buhr-stone rocks consists for the

most part of a series of hard aluminous and siliceous sandstones, which yield with difficulty to the leveling action of water, and hence within the region of their occurrence high rugged hills are the characteristic features, and in so far as the soils are derived from these rocks they are in general poor. These hilly areas are usually covered with a growth of long-leaf pines, with some oaks. Below the Buhr-stone is a black laminated clay, interstratified with beds of a greensand marl, and the lands which lie under the hills containing this mineral are always of most excellent quality.

South of this rugged country the land is comparatively level to within three miles of Evergreen, where a calcareous sandstone, holding beds of fossiliferous greensand containing a large percentage of lime, outcrops from the hillsides. South of this the county is underlaid with the white limestone, which, as a rule, is so covered with the sands and other beds of the Drift as to be of very little importance in the formation of the soils, except where, by a partial removal of these beds by denudation, it is brought near enough the surface to influence the loam soils overlying it. This is the case along the drainage slopes of a belt of land extending from the vicinity of Bellville southeastward toward Brooklyn. These lands lie contiguous to Murder, Beaver, and Bottle creeks, and form an interrupted strip of about six miles in width. Throughout this section are knolls of rather hard lime-rock of a yellow color, which make an excellent lime when burned, and which are generally quite fossiliferous. The lands below such outcrops of lime-rock are the best in the county, and have a red-loam soil with a stiff-clay subsoil, and a natural growth consisting of sweet gum, water oak, white oak, magnolia, cedar, short-leaf pine, and spruce pine. In this area are also outcroppings of the soft white limestone which is so universally used as material for building chimneys, since when freshly quarried it can be easily cut with an ax or saw. Lime-sinks are a characteristic feature not only of this area, but also of all the country underlaid with the limestone. The rocky knolls spoken of are not much in cultivation because of the rock fragments, but the soil is very rich and of a black color, and as the hills break off toward the lowlands there are many tracts of

black limy soil. These red and black lime-lands are considered the best farming lands in Conecuh. The highlands lying between the patches of lime-land are sandy, and of the usual pine-hills character.

Southward of the lime-lands, the county is gently undulating piny woods, with lime-sinks, and occasionally lakes or ponds which reveal the existence of the limestone beneath the sands. This rock makes its appearance along the banks of some of the streams. As a general rule, the surface materials which overlie the white limestone are sandy, with very little clay. From the porous nature of these beds, the water which falls upon them is rapidly absorbed and drained away by the underground channels with which the limestone is traversed, and thus causes very little erosion. The resulting face of the country is hence nearly level, sloping off very gently toward the water-courses. This is the nature of the rolling pine lands of the lower part of Conecuh, and, indeed, of the country southward into Florida.

From the above general account, it will be seen that while Conecuh county has a large proportion of sandy loam soils, with a growth of long-leaf pine, there are two or three belts across the county in which the calcareous matter of the underlying rocks brings about very desirable modifications of the prevailing soils, especially in the lower-lying areas. Where this marling of the soils has been effected by natural causes, its good effects are apparent, and there is no reason why the greensand marls, which are to be found in several parts of the county, should not be used with profit by the farmers on their poorer lands.

The choice farming lands of this county, as may be inferred, are the red lime-lands of Murder, Beaver and Bottle creeks, most of which have long been in cultivation, and before the war were held at high prices—$15 to $20 an acre. Since the war, many of them appear to have been somewhat neglected, though they are still fine lands. The cultivation on the other lands in the county needs no special notice. The use of commercial fertilizers is becoming general upon such lands, not only in this, but in the other counties of the State.

ABSTRACT OF THE REPORT OF REV. ANDREW JAY, OF JAYVILLA.

(This report refers to the region drained by Murder creek and the Escambia river.)

The soil varieties are: 1, the red upland soil lying on Beaver and Murder creeks, but above overflow; 2, the hummock or sandy bottoms reaching from the creeks to the table-lands, sometimes overflowed; and 3, pine lands, sandy, with clay foundation, and hilly.

Of these soils, the most important to the farmer are the red uplands, though constituting only one-fourth of the area. These lands are to be found in detached bodies, interspersed with the pine lands. The usual growth is white oak, beech, ash, hickory, elm and red oak. Most of the land of this kind has been cleared up. The soil is a light loam of reddish to blackish-red colors, three to six inches deep to a change of color, but which mixes so gradually with the subsoil that the exact depth is difficult to determine. The subsoil is of a heavier nature than the soil, is tough, but when exposed to the air, it becomes pulverized, and mixes readily with the surface soil, to which it seems to impart some fertility. It often contains pebbles, and rests upon rock at varying depths. This soil is easy of tillage, early, warm, and well drained, and yields good crops of cotton, corn, oats, potatoes and pease. Since the land has become worn, it seems to be best adapted to corn, oats and pease, as the cotton rusts. As it is, however, cotton makes about half the cultivated crop. Upon freshly cleared land, the stalk attains a height of five to seven feet; upon the worn land, three to five feet.

The sandy bottom lands are not described in detail. The pine hills occupy half or more of the area, and are interspersed with the creek lands, their usual growth being chiefly long-leaf pine, with dogwood and red and black-jack oaks. The soil is a light-colored fine sandy loam, one to two inches deep to a change of color; the subsoil is heavier, being a clayey loam, which is stiffer the deeper it is taken. The soil is easily tilled at all times, and is rather late and cold, but well drained. Most crops do well upon it, but cotton occupies the greater portion. The height attained depends upon the quality and quantity of the fertilizers used. When there is too much rain, there is a tendency of the plant to run to weed, which may be checked by topping or by running a furrow close to the roots.

About half of the red lands lie turned out, but after a long rest of twenty or thirty years, they will produce nearly as well as when new. The slopes are long and gentle, and the injury from washes comparatively slight, the valleys being often rather benefited by the settlings. The pine lands have been more generally kept up than the preceding, and only a small proportion of them has been turned out. The injury from washes is much greater with these than with the other lands. Horizontalizing and hillside ditching have been tried to a small extent, with good results where properly done.

ABSTRACT OF THE REPORT OF P. D. BOWLES, OF EVERGREEN.

The lowlands are the first and second bottoms of Beaver creek, and also the alluvial plains of Murder creek, and white-oak flats with water oaks and magnolias. The uplands are the rolling and level lands with gray, limy soil, partly sandy, bordering on the bottom lands of Murder creek and the Conecuh river. The greater part of this section has a red-clay subsoil.

Early planting in the lowlands is frequently injured by late frosts, and cold days give the cotton "sore-shin," and otherwise retard its growth. Want of rain in June, July and August, causes more damage than anything else, except the cotton worm. On the other hand, too much rain will produce the same effect, by causing the forms and young fruit to drop off. Early frost is never feared in this locality. The soils described are: 1, gray sandy uplands, with red-clay subsoil very near the surface; 2, level lime prairie, with lime-sinks and shell mounds; 3, thin pine lands, with gray sandy loam soil.

The gray uplands in the neighborhood of Evergreen constitute perhaps three-fourths of the arable lands. When well worn, the soil becomes red-colored, and the growth on such soils is of white, Spanish and water oaks, sweet-bay, magnolia, poplar and beech. The light soils are fine sandy loams of gray and red colors; the heavy soils, clay loams, of depths of color varying according to the length of time they have been under cultivation. The average thickness of the soil to a change of color is about ten inches. The subsoil, as a general thing heavier than the soil, is of a deep-red color, except in the more limy spots, where the color is yellow, and frequently contains fragments of soft lime rock, underlaid with the same at a depth of from three to twenty feet. About half this land is in cotton, which grows to a height of five or six feet.

The level lime prairies are found in a belt six miles wide, extending across the county, principally in township five. Oaks, walnut, hickory and birch are the principal trees. The light soils are gray, limy loams; the heavier are clay loams, of gray, brown and blackish to black colors. The subsoil is heavier than the surface soil, being a very soft yellow limestone, continuing some three feet to the hard limestone rock. It contains fragments of the soft lime-rock above mentioned. Tillage is rather difficult, both when too wet and when too dry; and when ill-drained, the soil is late and cold. It seems to be best suited to corn, though cotton is planted upon about half of the uplands, but on very little of the lowlands. The plant grows to a height of from four to seven feet, being most productive at five feet.

At least one-half of the county is composed of the sandy pine lands, especially the southern, northwestern and southeastern portions. Long-leaf pine is the characteristic tree, but with it, in places, are also oaks of several species and some hickory. The soil is a fine sandy loam, with clay in places, with whitish, gray, to blackish colors, according to length of time under cultivation. The thickness is six to eight inches to a change of color; subsoil rather heavier, being almost without exception yellow or red clay, containing rounded pebbles of quartz, especially along the branches. The underlying substance is either sand and gravel, or sometimes hard limestone rock at ten to twenty feet. Tillage is easy at all times, and the soils are early and warm when well drained, which is commonly the case. This land is best suited to sugar-cane and sweet potatoes, and only about one-fourth of the area is put in cotton, which grows from two to four feet in height, being most productive at three feet. From ten to twenty-five per cent. of the formerly cultivated lands are turned (less of the lime lands than of the others), and when reclaimed, these lands will often yield nearly as well as when new. Where the land is hilly, the uplands are often ruined

by the washing away of the soil, but the valleys are seldom injured, but, on the contrary, often improved, by receiving the washings from the higher lands. Very little systematic effort has ever been made to check this evil, except in the very best of the lands.

COVINGTON.

(See "Long-leaf Pine region.")

CRENSHAW.

Population: 11,726.—White, 9,118; colored, 2,608.

Area: 660 square miles.—Woodland, all. Long-leaf Pine Uplands, 435 square miles; Oak and Hickory or Brown-loam Uplands, 125 square miles; Hill Prairies, containing about 10 square miles of red lands, 60 square miles; Red Lime-lands, in lower part of county, 30 square miles.

Tilled land: 67,770 acres.—Area planted in cotton, 26,962 acres; in corn, 28,099 acres; in oats, 5,208 acres; in tobacco, 33 acres; in rice, 25 acres; in sugar-cane, 294 acres; in sweet potatoes, 558 acres.

Cotton production: 8,173 bales; average cotton product per acre, 0.30 bale, 429 pounds seed-cotton, or 143 pounds cotton lint.

Crenshaw county, lying between Butler and Pike, has many points of resemblance to each. It has already been remarked that as we go east the sands and loams of the Post-Tertiary appear to increase in thickness to the extent often of covering almost entirely the underlying rocks. For this reason the eastern counties depend for their soils and physical features generally to a very great degree upon these surface beds.

Crenshaw county has for its underlying strata the Lower Tertiary beds, and, in the northern tier of townships, the uppermost beds of the Cretaceous formation. These Cretaceous rocks consist of alternations of hard crystalline limestones and softer strata of calcareous clays. As a rule, these beds are covered with the Drift deposits, and exercise little influence upon the soils. A red soil, with small rounded lumps of brown iron ore, occurs in the northern part of the county, overlying a limestone ridge of the Cretaceous formation. The influence of the underlying lime-rocks is fre-

quently felt in the soil, giving rise to highly productive calcareous soils, and the washings of these lands improve very greatly the bottom lands of the streams contiguous to them. In the latitude of Rutledge a white limestone of considerable purity is to be found in the banks of the streams, and occasionally at higher levels. This has been burned, and makes an excellent lime for building purposes, and could be profitably employed on the lands.

The lower half of the county is, in general, piny woods, with areas of very good oak and hickory lands alternating with the prevailing pine lands. In a few localities in the extreme south of Crenshaw county occurs a kind of red lime-land, which results from the reaction of the white limestone upon the overlying red loam. These lands occur usually where the greater part of the overlying beds has been washed away and the limestone is thus brought near the surface, and lie in the vicinities of Leon and of Bullock, along tributaries of the Patsaliga, Conecuh, and Yellow rivers. They are of comparatively limited extent, and resemble, both in quality and origin, the lime-lands of Murder creek and other localities in Conecuh county.

A large proportion of the lands of Crenshaw are pine lands, and as a rule are deficient in lime. The occurrence of limestone over a considerable area through the center of the county might be turned to good account in improving these lands. Commercial fertilizers are now pretty generally used throughout the county in the culture of cotton, and where the subsoil is a red clay, as is the case over a large part of the county, these fertilizers do well.

ABSTRACT OF THE REPORT OF GEORGE W. THAGARD, OF RUTLEDGE.

The lowlands described are the first and second bottoms of Patsaliga river, together with cypress swamps and gallberry flats, and the uplands are the rolling and level lands contiguous to the same stream. In general, the uplands are preferred for cotton, for the reason that the lowlands are late, and the cotton, therefore, much more likely to be injured by frost.

The three most important soils described are: First, the high mulatto lands and gray oak and pine lands; second, the dark loam of Patsaliga river bottom above overflow; and third, the sandy bottom lands of the same stream. Of these soils the most widely distributed are the gray sandy uplands, making at least three-fourths of the county. The natural growth is long-leaf pine, oaks, hickory, gum, and cypress. In its physical characters

the soil presents the usual varieties of texture and color so often described for similar soils. The average thickness to a change of color to that of the subsoil is from two to six inches. The subsoil is either red clay or yellowish sand, or some intermediate grade between the two, and when undisturbed becomes quite impervious. It frequently contains rounded white pebbles of quartz, and is underlaid at greater or less depths by lime-rock in this vicinity. The soil is always easily tilled, and is cultivated in cotton, corn, oats, and sweet potatoes, but is best suited to cotton, which makes about one-half of the cultivated crop. The most productive height of stalk is three or four feet, but the height varies from two to six feet. A tendency to run to weed is sometimes seen in cotton growing upon fresh land, especially in wet seasons, and the best remedy is a stimulation of the growth by the liberal application of barnyard or commercial manures.

The Florida clover, or "poor man's trouble," is the greatest pest in the way of a weed. Perhaps a sixth of the originally cultivated land now lies turned out, but such land, when again taken into cultivation, produces very well if fertilized. In some localities there is much injury from washings, but no serious efforts have been made to check it.

MONTGOMERY.

(See "Central Prairie region.")

BULLOCK.

(See "Central Prairie region.")

BARBOUR.

(See "Central Prairie region.")

PIKE.

Population: 20,640.—White, 14,368; colored, 6,272.

Area: 740 square miles.—Woodland, all. Oak and Hickory Uplands, with Long-leaf Pine, 590 square miles; Pine Hills, 150 square miles.

Tilled land: 114,850 acres.—Area planted in cotton, 47,107 acres; in corn, 42,207 acres; in oats, 5,424 acres; in wheat, 72 acres; in rye, 23 acres; in sugar-cane, 400 acres; in sweet potatoes, 883 acres.

Cotton production: 15,136 bales; average cotton product per acre, 0.32 bale, 466 pounds seed cotton, or 152 pounds cotton lint.

The sandy ridge, with a substratum of marl and sometimes limestone of the Upper Cretaceous age, passes through the northern townships of Pike county. Further

east it is known generally as Chunnenugga ridge, and it is a notable feature of the landscape, as well as characteristic from an agricultural standpoint. Upon the level portions of this ridge the soil is sandy and comparatively poor, but where the drainage has removed these surface beds the calcareous strata are brought to the surface and produce lasting and productive soils. The bottom lands, which receive the washings from these calcareous beds, are of the best character. Southward of this ridge there is a strip of calcareous clayey land, varying in width from three to five miles, and running east and west through the county. The southern limit of the Cretaceous formation is seen a few miles north of the town of Troy, where its strata are exposed in the banks of the Conecuh river. This limit of the two formations is, however, concealed, except along the banks of streams, by thick beds of sand and loam, which form the soils generally thence southward.

East of Troy, according to Thornton, in the "Pocoson" region, the valleys, which have the luxuriant growth and appearance of swamps, are surrounded on three sides by ridges of snow-white sand, on which grows only a scrubby oak, covered with long moss. In the latitude of Troy, and a few miles below, calcareous beds of the Lower Tertiary formation outcrop in places, producing a stiff limy and clayey soil of considerable fertility, but seven or eight miles south of Troy the siliceous and argillaceous sandstones of the Buhr-stone group come to the surface, and, as usual where this is the case, the soils are poor and the prevailing growth long-leaf pine.

The county below Troy is generally piny woods, with alternations and admixtures of oak and hickory lands. As is often the case, the pine lands are upon the level dividing plains between the water-courses, while the oaks and other trees occupy more generally the slopes and lower levels. In the vicinity of Brundidge there is a rather stiff clayey soil of much fertility, and this is considered one of the best farming areas of the county.

In Pike county the upland soils are, as a rule, poor in lime; the lowlands in places are better in this respect. A bed of tolerably pure limestone, which outcrops occasionally

in the central and western parts of the county, might be profitably used to remedy this deficiency. There are also some beds of a greensand marl within the county limits. The clayey nature of most of the upland subsoils allows commercial fertilizers to be profitably used.

The great cotton mart for this and also for the adjoining counties is Troy, and the crop is hauled to this place from great distances, most of the wagons which carry cotton to the market returning with bags of guano and other commercial fertilizers.

COFFEE.

Population: 8,119.—White, 6,831; colored, 1,288.

Area: 700 square miles—Woodland, all. Pine Uplands, 340 square miles; Rolling or Undulating Pine Lands, 360 square miles.

Tilled land: 42,126 acres.—Area planted in cotton, 16,431 acres; in corn, 18,668 acres; in oats, 2,370 acres; in rye, 31 acres; in wheat, 22 acres; in rice, 21 acres; in sugar-cane, 254 acres; in sweet potatoes, 474 acres.

Cotton production: 4,788 bales; average cotton product per acre, 0.29 bale, 414 pounds seed-cotton, or 138 pounds cotton lint.

The northern part of Coffee county, where the Claiborne beds are the underlying rocks, is in general much more broken and hilly than the southern, which is underlaid with the Vicksburg or white limestone. Above Elba there is a good deal of what are usually called "red-clay hills," alternating with sandy bottoms. The growth upon such land consists of long-leaf pine, with the species of upland oaks, sour gum, etc., and the soil is fairly productive. As representing the average composition of this class of upland soils we may take the analysis of an oak upland soil from near Lawrenceville, Henry county, No. 84, page 261.

Below Elba, along the water-sheds at least, the county is nearly level or gently undulating, with here and there a basin-shaped depression (sometimes filled with water, forming a pond or lake, sometimes dry)—evidences of the existence of the limestone below. This rock, however, rarely

comes to the surface, except along the water-courses, but is covered with thick beds of the Stratified Drift materials. These materials upon the higher level areas are prevalently sandy; while along the drainage slopes the more clayey materials are to be found, and it is only in these latter places that the soil is cultivated. The sandy level areas away from the water-courses are covered with long-leaf pine forests, which are used as pastures for cattle and sheep. Some very good farming tracts are to be met with in the vicinity of the creeks and branches. It is perhaps needless to say that human habitations are rarely met with upon these pine barren plateaus.

Coffee is a fair representative of the lower counties of the State. It is well drained by Pea river, Double Branches creek, and their numerous tributaries.

ABSTRACT OF THE REPORT OF M. G. STOUDENMIER, OF ELBA.

The soil varies from fine to coarse sandy or gravelly loam, with a growth of long-leaf pine, intermixed with various species of oak and hickory, and undergrowth. The color varies from light-gray to reddish and other dark colors; thickness, about four inches before its color is merged into that of the subsoil. The latter contains usually more or less of yellowish clay, which bakes hard upon exposure, and is often very impervious. It frequently holds white quartz pebbles. It is easily tilled under all circumstances, and is warm and well drained.

The chief crops cultivated are cotton and corn, the former occupying about 50 per cent. of the cultivated area. The stalk attains usually a height of three and a half feet, but is more productive when at least four feet in height. The most troublesome weed (exclusive of grasses) is the Florida clover. About one-half of the land originally cultivated now lies turned out, but some of it is being reclaimed, and for two or three years it produces nearly as well as when fresh. From the nature of the soil there is considerable injury from washings, the valleys being often damaged to the extent of 10 per cent. by the washings from the uplands. As yet no efforts have been made to check the evil.

DALE.

Population: 12,677.—White, 10,553; colored, 2,124.

Area: 650 square miles.—Woodland, all. Pine Uplands, 420 square miles; Undulating Pine Lands, 230 square miles.

Tilled land: 68,413 acres.—Area planted in cotton, 27,076 acres; in corn, 31,867 acres; in oats, 5,114 acres; in wheat,

59 acres; in rye, 24 acres; in rice, 49 acres; in sugar-cane, 373 acres; in sweet potatoes, 872 acres.

Cotton production: 6,224 bales; average cotton product per acre, 0.23 bale, 327 pounds seed-cotton, or 109 pounds cotton lint.

Dale county, in its geological structure and in its surface features, bears a close resemblance to Coffee county, on the west. The strata of the Claiborne and Vicksburg groups of the Tertiary are the underlying rocks, and these are covered by heavy beds of sands, loam, and pebbles to the extent of concealing almost entirely the underlying country rocks. These two groups of the Tertiary formation underlie each about half of the county, the Claiborne in the north and the Vicksburg in the south. Neither is largely concerned in the formation of arable soils, since they are derived almost exclusively from superficial beds. Upon the topography, however, these lower rocks exert a decided and easily recognized influence. To appreciate this, one has only to consider the difference between the broken and hilly aspect of northern Dale with the level, or at most gently rolling, pine forests of the southern part. For several miles around the county seat (Ozark) deep beds of sand are a notable feature.

In the northern part of the county, where the drainage has cut through the overlying deposits, the country rock, which is generally an aluminous sandstone, full of shells or casts of shells, is exposed. Some varieties of this rock are, when freshly quarried, easily cut with a saw or other implement, and blocks of it are extensively used in the construction of chimneys and pillars to the houses. In this northern part there is usually a red loam substratum to the soils, while in the southern part the loam, though not entirely absent, is comparatively unimportant. At Newton it is present in great thickness. Below Newton the irregularities of surface are very slight, ten or fifteen feet being often the difference in elevation between the water-courses and the dividing land. The surface soil is mostly sandy, and the country rock is seldom seen until near the Geneva county line, where there are several large limestone springs and outcrops of a white fossiliferous limestone. This rock appears to have generally very little influence upon the over-

lying soil; but there are spots where the soil is a calcareous clayey loam, formed by the reaction of lime rock upon the overlaying loam. The rich lime lands of Murder creek, in Conecuh county, are of a similar nature.

ABSTRACT OF THE REPORT OF J. C. MATTHEWS, OF CRITTENDEN'S MILLS.

The soils enumerated are red clayey loam, gray bottom soil, and the sandy soils. The most important in an agricultural sense are red loams, which make perhaps a tenth of the cultivated area. This soil, which is so prevalent in the counties further north, is seen in this county only in spots. Its natural growth is oak, hickory, and gum, with short and long-leaf pines added in accordance with the variations in the quantity of the soil. It is a clayey loam of buff to brown colors of an average thickness of six inches before the color changes to that of the subsoil, which is heavier than the surface soil, being a joint clay and white marl, and often contains rounded pebbles of white quartz, and is itself underlaid by a black rock at fifteen feet depth. It is considered difficult of tillage, since it gets dry and hard. It is, however, early, and produces well the usual crops, to all of which it seems to be well adapted.

The bottom lands of the Choctawhatchee river are next in importance. Their natural timber is a mixture of oaks, hickory, poplar, gum, etc. The lighter soils are sandy loams; the heavier are clayey loams. The colors are whitish, gray, buff, brown, mahogany, blackish to black, and the average thickness to a change of color is two or three inches. The subsoil is a joint clay, underlaid with a black rock at ten feet depth. This soil is early, but rather difficult of tillage, and is considered best suited to the cotton crop. Between these two extremes of soil there are all intermediate grades.

About two-thirds of the red or brown-loam lands and a fourth of the Choctawhatchee bottoms are in cotton, which is most productive at a height of three feet.

About one-fourth or one-fifth of these lands, once in cultivation, now lie turned out, and when taken again into cultivation do not produce very well. The land suffers to some extent from washings, but no well-directed efforts have been made to check the evil.

HENRY.

Population: 18,761.—White, 11,994; colored, 6,767.

Area: 1,000 square miles.—Woodland, all. Oak, hickory, or Brown-Loam Uplands, 100 square miles; Pine Uplands, 550 suare miles; Undulating Pine Lands, 340 square miles; Red Lime-lands, 10 square miles.

Tilled land: 137,348 acres.—Area planted in cotton, 54,305 acres; in corn, 48,661 acres; in oats, 7,902 acres; in rye, 263 acres; in wheat, 193 acres; in tobacco, 24 acres;

in rice, 25 acres; in sugar-cane, 671 acres; in sweet potatoes, 1,266 acres.

Cotton production: 12,573 bales; average cotton product per acre, 0.23 bale, 237 pounds seed-cotton, or 109 pounds cotton lint.

The upper half of Henry county is underlaid with the strata of the Claiborne group, and the lower by those of the Vicksburg, and a coating of drifted materials of considerable thickness covers these throughout the county. These superficial beds present notable differences in different sections. In the northern part of the county they are characterized by the generally red or orange color of the subsoil, which contains a large proportion of clay, and which lies upon reddish or yellow sands, frequently containing gravel. The soils in this section vary in the proportions of sand and loam in different localities. Upon the water-sheds the sandy soils, are as a rule, predominant, while upon the slopes the more loamy soils prevail. General reasons for this distribution have been mentioned before.

The topography in the upper part of the county is, like the soil, much more varied than in the lower. In the lower half the sandy soils prevail, and comparatively level pine woods constitute the landscape very generally. The drainage is principally into the Chattahoochee river, but a small area in the northwestern part is drained by the Choctawhatchee. The better class of upland yellow-loam soils, which are prevalent in the upper part of the county, are in chemical composition represented by the analysis of the soil from near Lawrenceville, given on page 261.

In the southwestern corner of the county, in the drainage basin of Big creek, there are a few miles of red lands of calcareous nature, similar to the red lands of Jackson county, Florida, and of the adjacent part of Geneva county. This land, which has its counterpart in the lime-lands of Murder creek, in Conecuh county, is produced by the action of the limestone upon the loam soil overlying it. The agricultural peculiarities of the first-mentioned soils are given in the following abstract.

Henry county shows agriculturally no peculiarity. Cotton is cultivated on upland and bottom soils of the usual

character afforded by the Drift and Loam which overspread so great a proportion of the southern part of the State. The river lands here, as elsewhere along the Chattahoochee, have a large proportion of fragments of mica or isinglass mingled with the other ingredients of the soil.

ABSTRACT OF THE REPORT OF A. M'ALLISTER, OF SHORTERVILLE.

The most important soils in the vicinity of Shorterville are the river bottom soils, and of these the "isinglass" soils are considered best, because most certain. The usual bottom growth of hickory, oak, ash, walnut, sweet gum, bay, etc., is found. Both soil and subsoil are sandy loams of various colors; whitish and gray most abundant. Tilling qualities easy under all circumstances. The soil is early, warm, and well drained as a rule, and is well suited to the production of cotton, corn, oats, rye, potatoes, sugar cane, field pease, etc. The upland soils of the northern part of the county are fine to coarse sandy loams, heavy, clayey loams in places, resting upon a sandy, sometimes gravelly, clay; thickness of the soil to a change of color, variable—12 to 15 inches. They are all easily tilled, and are warm, early, and well drained. These usual crops are all cultivated with success.

The pine lands in the upper part of the county are not characteristic, but in the middle and southern sections pine forms almost the exclusive growth, except along the streams. The surface soil is generally a dark-gray or brown sandy loam, the subsoil a sandy clay, with occasionally pebbles. The soil is early, well drained, easy of tillage, and suited to the usual crops: cotton, corn, sugar-cane, etc.

About half the cultivated land of each of these soil varieties is planted in cotton, which grows to a height of from three to five feet, being most productive at about four feet.

Only a small proportion of the river lands are turned out (from five to ten per cent. of the other varieties), and they all improve by resting, producing for a few seasons, after being reclaimed, nearly as well as when fresh.

LOWER PRAIRIE REGION, OR LIME-HILLS.

In this region are included parts of the following counties: Choctaw,* Washington,* Clarke,* Monroe,* Conecuh,* Covington,* Crenshaw,* Geneva,* and Henry.*

CHOCTAW.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

WASHINGTON.

(See "Long-leaf Pine region.")

CLARKE.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

MONROE.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

CONECUH.

(See "Oak and Hickory Uplands, with Long-leaf Pine."

COVINGTON.

(See "Long-leaf Pine region.")

CRENSHAW.

(See "Oak and Hickory Uplands, with Long-leaf Pine."

GENEVA.

(See "Long-leaf Pine region.")

HENRY.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

LONG-LEAF PINE REGION.

In this region are included parts of the following counties: Washington, Mobile, Clarke,* Baldwin, Monroe,* Conecuh,* Escambia, Covington, Geneva, Coffee,* Dale,* and Henry.*

WASHINGTON.

Population: 4,538.—White, 2,807; colored, 1,731.

Area: 1,050 square miles.—Woodland, all. Undulating Pine Lands, 800 square miles; Lime-Hills and Shell-prairie lands, 150 square miles; Pine Hills, 100 square miles.

Tilled land: 8,936 acres.—Area planted in cotton, 3,280 acres; in corn, 4,259 acres; in oats, 464 acres; in rice, 67 acres; in sugar-cane, 90 acres; in sweet potatoes, 448 acres.

Cotton production: 1,246 bales; average cotton product

per acre, 0.38 bale, 543 pounds seed-cotton, or 181 pounds cotton lint.

In the northern part of Washington county there is a belt, varying in width from two to ten miles, in which lime-hills and prairies are the characteristic feature. The material upon which these soils depend for their origin is an impure whitish-gray limestone, having sometimes a greenish cast. This rock resembles to some extent the Rotten Limestone of the Central prairie region, and like it, in disintegrating under the action of the weather, yields a grayish, waxy clay, which, mixed with vegetable matter, acquires a black color, like some of the central prairie soils.

This stiff black soil is difficult to till, but very fertile. Some parts of the rock crumble down into a fine, loose, black material called shell-prairie soil, in which are small pieces of the crumbling rock, sometimes filled with shells. This is one of the best of the lime-hills soils, rarely failing to bring good crops either of cotton or of corn. It is timbered with dogwood, black and white oaks, sweet gum, ash, short-leaf pine, and buckeye.

An intermixture of stiff calcareous clay with the red loam which forms the surface over the greater part of the northern portion of the county, gives a stiff, mahogany-colored or yellowish soil, like the post-oak soil of the central region, and like that is timbered with post oaks and a few short-leaf pines, with occasionally a sweet gum and a hickory, all draped with long moss. This soil, like the first named, is rather difficult to cultivate, but is highly productive. The prairie belt is very variable in width, and in places the piny woods extend entirely across it, while, on the other hand, narrow strips of prairie extend for miles out into the piny woods along some of the streams; and everywhere the prairie soils are interspersed with the sandy and loamy soil of the drift, which spreads over all the older rocks of this county and forms the great majority of the soils.

The topography of the lime-hills is quite characteristic. The hills are very steep, and have usually very little level land on top; but near the western border of the county it is not unusual to find as much as 100 acres in a body of tolerably level prairie land. As we go eastward these level

tracts diminish in size and frequency, and the prairie belt consists of the genuine lime-hills. While under continuous cultivation the soil of the lime-hills does not wash so badly as might be expected from the steepness of the slopes, but when abandoned the bare rock very soon makes its appearance at the surface on the bald hill-tops.

Another variety of white limestone, geologically below that just described, underlies a very large part of Washington county, probably down to the Mobile county-line, but as a rule it does not take any prominent part in the formation of the soils, nor does it materially influence the topography.*(a)* Most of the territory underlaid by it is rolling or undulating piny woods with sandy soils and with subsoils of two kinds. The soils with yellow, sandy subsoil are very poor, the growth long-leaf pine, black-jack, turkey, and high-ground willow oaks; but where the subsoil is a little stiffer and of a reddish color the lands are very fair, and are timbered with Spanish and other upland oaks in addition to the long-leaf pine.

Near the State line, southwest of the Prairie region, the land is a little more broken, passing westward in Mississippi into pine hills.

North of the lime-hills belt, in the extreme upper part of the county, there are other hilly pine lands, very poor, the surface of which is generally covered with fragments of sandstone and claystone (the latter usually called *chalk*). These chalk hills are best displayed in the lower part of Choctaw county, as only a very small part of Washington is of this character.

The creek-bottom lands throughout the lime-hills belt, are good farming lands, as are also sometimes those of the chalk hills north of the prairies. This, in the latter case, is caused by the presence of marly beds which are sometimes brought to the surface in the drainage valleys of the stream. In the rolling piny woods of the lower part of the county the bottoms are, as a rule, sandy, though generally

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a The historically, as well as geologically, well-known Saint Stephens bluff is in its upper portion formed of this rock, while the other variety of limestone lies at the base of the bluff. This bluff is 100 feet in height, by barometric measurement.

productive for a time. The lowlands of the river, chiefly the second bottom, are good farming lands, the soil being a sandy loam, easy to till and productive. In certain localities it is improved by the calcareous washings of the uplands. The lower part of the county, while of little value for farming, affords a splendid pasturage for cattle.

The high yield per acre (0.38 bale) is due to the fact that most of the cotton is produced either upon the highly fertile river lands or the equally rich lime lands in the northern part of the county.

In the piny woods which forms so large a proportion of the area of the county, the cultivation of cotton is not so profitable as stock-raising, timber-cutting, and the production of turpentine.

ABSTRACT OF THE REPORT OF R. M. CAMPBELL, SAINT STEPHENS, AIDED BY E. A. GLOVER, JOHN STARKE, AND OLIVER PRINCE.

There are three principal varieties of soil: First, upland sandy soil, of gray to yellowish colors, covering over two-thirds of the county; second, river bottom, occupying a large portion of the townships on the eastern border of the county; and third, lime-lands (black prairie, shell prairie), occupying a large portion of the northern tier of townships in the county.

The sandy uplands are timbered chiefly with long-leaf pine and black-jack, to which, in spots, the other varieties of oak, dogwood and hickory are added. Its soil is from three to twelve inches deep before its color changes to that of the subsoil, which is more clayey, easily permeable by water, but bakes hard when exposed to the sun where not cultivated, and contains, in places, concretions of ferruginous sandstone. This soil is easily tilled under all circumstances, and is always well drained.

The river bottom soil consists of a fine sandy loam on the river front, a heavy clay loam on stiff lands, and a putty-like loam on black land. The colors are brown, blackish to black; and thickness from eighteen to twenty feet, below which sand has sometimes been noticed. White oak, ash, cotton-wood, hickory, sweet gum, etc., are the prevailing trees. The land is easily tilled in wet or dry weather.

The lime lands occupy a large part of the northern tier of townships in the county from the river westward. The natural growth is cedar, ash, hickory, oak, chestnut, etc. The soil is a heavy clay loam and a mellow shell prairie, putty-like in places, of gray, brown and blackish colors, alternating or mixed; thickness about two feet to the subsoil, which, where the lime-rock is not near the surface, is a tough yellow clay, turning black where cultivated (not otherwise), very impervious if not disturbed, and containing lumps of the lime-rock filled with sea shells. Beneath the subsoil there is, at depths varying from two to ten feet, the lime rock of the country. Tilling qualities easy after being once broken up, especially in dry seasons. The shell land is mellow, as is also the stiff land, after being

plowed in the spring. The soil is early and warm when well drained, which is effected only by ditching.

The soils of Washington county are well suited to cotton, corn, and other grains, and sweet potatoes, the former being cultivated upon two-thirds to three-fourths of the cultivated lands. On the uplands, the average height of stalk is three feet; on the bottom and lime lands five to six feet, and is more productive the higher the stalk. Wet weather often causes the stalk to run to weed, especially on the shell prairies and lime-lands. Topping in July is the usual remedy, but some farmers think their mode of plowing avails. The average seed-cotton product of fresh land is from 300 to 600 pounds per acre on the uplands, 1,000 to 1,200 pounds on the lime-lands, and 1,300 pounds on the river lands, 1,545 pounds being needed to make a standard 475-pound bale, the staple of which rates from low middling to middling. After ten to twenty years' cultivation, without manure, the yield is reduced at least one-half on sloping or hilly lands, and not so much on the level bottoms, and about 1,600 pounds are needed to make a bale. There is no material deterioration of the fiber, except that it is thought to be a little shorter from worn land. Information on this point, however, is not definite. The troublesome weeds are crab-grass, Florida clover, morning-glory and coffee-weeds, and cockleburs, tie-vine and Indian potato or hog-root on the richer lands. From one-third to three-fourths of formerly cultivated lands are turned out (a less proportion of the lime-lands than of the others), and when again taken into cultivation, they produce much better than when last tilled, but not quite as well as when fresh. The uplands and the lime-lands are injured by washes, especially the hill-tops, the valleys being usually rather benefited by the washings. The river lands are injured by water only by overflows. Little effort has been made to check this evil.

MOBILE.

Population: 48,653—White, 27,187; colored, 21,466.

Area: 1,290 square miles.—Woodland, all, except Coast Marshes. Rolling pine lands, 820 square miles; Pine, flats, 470 square miles.

Tilled land: 8,998 acres.—Area planted in cotton, one acre only returned; in corn, 1,639 acres; in oats, 139 acres; in rice, 191 acres; in sugar-cane, 151 acres; in sweet potatoes, 776 acres.

Cotton production: One bale returned.

The statistics above given show that Mobile county has a comparatively small area of cultivated land. With respect to its geological structure, there is some uncertainty, though it seems probable that the white limestone underlies the greater part of the county, or at least the upper part as far south as Beaver Meadow and Chickasabogue, where lime-

sinks show the presence of a limestone below the surface. The surface beds throughout, except in the extreme south, are the Stratified Drift and Loam.

The county is gently undulating, though the water-sheds have considerable elevation above the sea. The Citronelle plateau, where crossed by the railroad, is 317 feet and the summit 333 feet above tide. All the drainage is into the Mobile river and bay on one side, and into the Escatawpa river on the other. The prevailing timber growth in the county is the long-leaf pine, which has been extensively cut for timber in all places where accessible to streams deep enough to float out the logs. The open pine woods afford most excellent pastures.

The characters of the principal soil varieties may be seen from the following abstract of the carefully written report of Professor J. P. Steele, of Citronelle, which refers to the lands in the northern part of the county, the lowlands along the Mobile river and bay, and the uplands on the Citronelle plateau.

The river, the bay and the various railroads furnish ample facilities of transportation for the various products of Mobile county.

Cotton is not cultivated, except in small packages for home use, and the attention of the farmers is generally turned to the production of early vegetables and southern fruits for the market.

ABSTRACT OF THE REPORT OF PROFESSOR J. P. STEELE, OF CITRONELLE.

The soils are: first, the red sandy loam with clay subsoil, peculiar to all the upland plains; second, the dark loamy soil along the bottoms of Mobile and Tombigbee rivers; and third, the yellowish sandy loam along the western shore of the bay.

The chief soil is the first named, which is the soil of the uplands throughout the county. Its natural timber is predominantly the long-leaf pine, but other trees, especially oaks, are not uncommon. The top soil is the usual sandy loam of whitish to gray, buff, orange, and blackish colors; thickness, ten inches. The subsoil on the uplands is a red tenacious clay with a small proportion of sand, and makes good bricks. It contains in some places a few white rounded pebbles of quartz. Below the subsoil is sand, capped by a ferruginous sandstone at the depth of ten to twenty feet. Vegetables for the northern market form the chief products of the soil.

The black bottom lands make one-eighth of the cultivated area in the region described. Its timber consists of oaks, hickory, elm, magnolia, bay,

cypress, sweet and sour gums. The top soil is usually a clay loam with a good deal of vegetable matter, of dark to nearly black colors, and many inches in thickness.

The flat pine lands make an eighth of the cultivated area in question. Its timber consists mainly of long-leaf pine, with magnolia, bay, cypress, etc. The top soil is a sandy to clayey loam of a yellowish color ten inches in thickness, with a yellowish clay loam as subsoil. It seems to be best adapted to the production of vegetables and fruits, oranges, etc. These three soils represent pretty nearly the different varieties occurring in the county.

CLARKE.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

BALDWIN.

Population: 8,603.—White, 4,890; colored, 3,713.

Area: 1,620 square miles.—Woodland, all, except Coast Marshes; Rolling Pine lands, 900 square miles; Pine flats, 720 square miles.

Tilled land: 7,698 acres.—Area planted in cotton, 1,384 acres; in corn, 2,041 acres; in oats, 350 acres; in rice, 121 acres; in sugar-cane, 81 acres; in sweet potatoes, 484 acres.

Cotton production: 638 bales; average cotton product per acre, 0.46 bale, 657 pounds seed-cotton, or 219 pounds cotton lint.

In physical and geological features Baldwin county resembles Mobile, which it adjoins on the east. The northern half of the county is more or less undulating, and is covered with a growth chiefly of long-leaf pine; the southern half is more level, and is timbered with the same tree and the Cuban pine. This general statement, however, is to be taken with some allowance, for between Mobile bay and the Perdido river, at Montrose, the water-shed is two hundred feet above the bay, and it is the highest land on the coast between the Rio Grande and Navesink *(Haines)*. The waters flow into the Perdido river on the east and into the Alabama and Mobile rivers and Mobile bay on the west. In the western part of the county, above the bay, is a considerable tract of marshy land in the delta of the river.

From the statistics, it will be seen that the county is rather thinly settled, and that a comparatively small proportion of the area is under cultivation. Much of the

county is a natural pasture, and large herds of cattle and sheep are sustained, and, where accessible to streams, lumbering is an important industry.

All the cotton, or by far the greater proportion of it, is produced in the northern part of the county, and, as the high yield per acre shows, with the aid of fertilizers. Where cultivated, the cotton is shipped to Mobile by boat or by rail.

MONROE.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

CONECUH.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

ESCAMBIA.

Population: 5,719.—White, 4,106; colored, 1,613.

Area: 1,000 square miles.—Woodland, all. All Rolling Pine lands.

Tilled land: 6,934 acres.—Area planted in cotton, 278 acres; in corn, 3,699 acres; in oats, 869 acres; in sugar-cane, 83 acres; in rice, 405 acres; in sweet potatoes, 494 acres.

Cotton production: 94 bales; average cotton product per acre, 0.34 bale, 486 pounds seed-cotton, or 162 pounds cotton lint.

Escambia lies wholly within the long-leaf pine region. Geologically, its structure is simple. The white limestone of Vicksburg age underlies certainly the northern part and probably the whole of the county, though coming to the surface but rarely. Upon this are spread the materials of the Stratified Drift, which here, as in so many other places, form the soil. The Conecuh and Escambia rivers, with their tributaries, drain the entire county, except a small portion of the northwest corner, which is drained by Little river, flowing into the Alabama, and another small portion in the southeast drained by a tributary of Yellow river.

The county is, in general, a level pine woods, gently undulating and unbroken, save by the small valleys of the creeks and branches, and by occasional ponds and lime-

sinks. The soil is uniformly a light sandy loam of prevailing light colors, and is comparatively poor. Along the Conecuh river especially there are bodies of good bottom or swamp land. The pine woods make here, as elsewhere, a fine natural pasture, and cattle-raising is an important industry. The magnificent pine timber is also a source of profit to many of the inhabitants. The high yield of the few acres planted in cotton shows that this staple is cultivated only in favored spots or with fertilizers.

ABSTRACT OF REPORT OF JOHN W. STEPHENSON, OF DOUGLASVILLE.

The upland soil is very thin, extending widely in vast unbroken tracts, and is not well suited to cotton unless manured. The lowlands are quite productive, but are sometimes liable to overflow, and the crop is thus lost. For this reason the uplands are preferred, and with manure they give very fair returns. Since the war comparatively little cotton has been cultivated; it is planted upon most of the varieties of soil.

The most fertile soil is found in bodies of five to ten acres along the Conecuh river bottom. The natural growth is spruce pine, oaks, hickory, chestnut, birch, etc. The soil is of the usual swamp or bottom-land character, with subsoil often containing pebbles, and sometimes underlaid with the ferruginous sandstone so common in the Stratified Drift. In dry seasons this soil is easily tilled, but sometimes tilled with difficelty in wet weather. Corn, pease, and sweet potatoes are the most abundant crops, but cotton does well wherever tried. Very little is raised for the market, and no information is at hand concerning the quality of staple, etc. On account of its position, this kind of land seldom suffers from washing.

Cotton is shipped by rail to Mobile or Montgomery.

COVINGTON.

Population: 5,639.—White, 4,968; colored, 671.

Area: 1,030 square miles.—Woodland, all. Undulating or Rolling Pine lands, 720 square miles; Lime-hills, 50 square miles; Pine Uplands, 260 square miles.

Tilled land: 19,326 acres.—Area planted in cotton, 4,176 acres; in corn, 10,558 acres; in oats, 2,114 acres; in rice, 47 acres; in sugar-cane, 147 acres; in sweet potatoes, 466 acres.

Cotton production: 1,158 bales; average cotton product per acre, 0.28 bale, 399 pounds seed-cotton, or 133 pounds cotton lint.

The rocky substratum of Covington county is made up of the strata of two of the groups of the Tertiary formation,

viz: the Jackson and the Vicksburg. The white limestone of the latter group is exposed where the overlying Drift materials have been removed by denudation throughout the whole county, except, perhaps, the extreme southern portion. As a rule, this rock is too deeply covered with the Drift sands and loam to have much influence upon the soils, except in a few areas of limited extent, where red lime-lands similar to those of the adjoining county of Conecuh are found in the upper part of the county. Otherwise, the upland soils are of the usual varieties afforded by the Stratified Drift. The soils, therefore, are uplands sandy loams of varying degrees of fertility, but usually light, forming the great bulk of the lands. These have a growth of long-leaf pine, alternating with the various species of upland oaks. The pines occupy, in general terms, the higher areas, while the oaks and hickories are found more frequently along the drainage slopes of the streams; positions determined in great measure probably by the varying proportions of sand in the soils from which these trees derive their sustenance. Upon the higher lands, where by the long-continued action of the rains the specifically lighter materials constituting the clay have been carried off from the surface, the sandier portions are left to form the soil. Upon slopes, however, where running water has been active, both the lighter and heavier materials are removed together, and the original loamy character of the Drift deposits has been preserved more or less unchanged.

Upon the nearly level gently undulating areas in the lower part of the county vast forests of long-leaf pine prevail, with an undergrowth of grass and leguminous plants, which afford pasturage for great numbers of cattle, sheep, and swine. The forests themselves, where accessible, are heavily drawn upon for timber.

The bottom lands are of the usual character, and are generally fertile. From their liability to overflow, however, they are often less desirable than the uplands, where, with moderate outlay for fertilizers, good crops of cotton are almost certain to be made. The chemical nature of the pine uplands soils is very well seen in the analysis given on page 288 of a soil from 13 miles east of Andalusia. These

soils, like the sandy, rather infertile soils of the Coal Measures and parts of the older formations of the State, while intrinsically poor, are yet rapidly coming into use with fertilizers.

Agriculturally, Covington county is like Conecuh, with the exception that the lime-lands here are of very limited extent, and nearly the whole county has the character of the long-leaf pine lands.

The cotton from this county is usually shipped from Troy, Greenville, or Evergreen, to which markets it must be hauled a great distance in wagons.

GENEVA.

Population: 4,342.—White, 3,829; colored, 513.

Area: 590 square miles.—Woodland, all. Undulating Pine lands, 560 square miles; Red Lime-lands, 30 square miles.

Tilled land: 17,664 acres.—Area planted in cotton, 4,947 acres; in corn, 9,476 acres; in oats, 1,705 acres; in sugar-cane, 118 acres; in rice, 54 acres; in sweet potatoes, 350 acres.

Cotton production: 1,112 bales; average cotton product per acre, 0.23 bale, 327 pounds seed-cotton, or 109 pounds cotton lint.

Geneva county is underlaid throughout its entire extent with the white Vicksburg limestone, which, as usual, exerts comparatively little influence on the cultivable soils. Exception to this is noticed in the eastern part of the county, in the drainage area of the Chipola river, where a fine lime-land is well known for its fertile character. This sort of calcareous soil is much more prevalent in the adjoining county in Florida, whose red lime-lands have a wide reputation.

The arable soils are in great measure derived from Stratified Drift and Loam, and exhibit the usual varieties. The proportion of red or yellow loam in the soil and subsoil seems to decrease, in general, as we go south, and the proportion of sand to increase in the same direction. Between Millville and Geneva the various species of oaks are asso-

ciated with the long-leaf pines, showing a very fair quality of soil. Northwest of Geneva, along the divide between Double Bridges creek and Pea river, pine woods, with scarcely any admixture of other trees, prevail; but occasionally upland willow and small post and black-jack oaks are associated with the pines, constituting a regular pine-barren growth. Coarse tufts of wire-grass form the undergrowth almost universally, except in the numerous boggy places, where a rich and peculiar flora is commonly seen.

Until a few years past the cultivation of cotton in this county has received very little attention, the inhabitants being chiefly engaged in the lumber business and in cattle and sheep raising. With the use of guano these pine lands bring very fair crops, often a bale to two acres.

With the exception above noted of a small area of lime-lands in the southeastern part of the county, the pine woods form all the uplands of Geneva. The composition of the soil is similar to that of the Covington county soil, (analysis given on page 288), which is, however, a better soil than that of the average pine woods.

The white Orbitoidal limestone of the Vicksburg age is to be seen in many localities in Geneva where the drainage has removed the overlying sands, as along the banks of the Choctawhatchee river and other large streams. This river is navigable to the town of Geneva, and was formerly one of the principal outlets for products of the county. Most of the timber still finds its way to market by this stream, though the cotton is now hauled in wagons to Troy, at a cost of $2.50 per bale.

ABSTRACT OF THE REPORT OF W. N. BRANDON, OF GENEVA.

The lowlands are the dark-gray bottom lands, sand hummocks, and gall-berry flats. The uplands vary from light gray to red, according to the proportion of loam which is mixed with the sand, and are preferred, as the cotton can be planted earlier, with consequently less liability to damage from early frosts and worms. The river lands are nearly all subject to overflow, and are not so certain.

The gray upland soils have a yellowish subsoil down to the clay (reached at 18 inches), and the mahogany and red soils have a red subsoil. The timber is long-leaf pine, with post oak, hickory, broad-leaf black-jack, red oak, etc. These soils are early, warm, and well drained, and well suited to cotton, corn, sugar-cane, rice, potatoes, etc.

About half the cultivated area about Geneva is in cotton, which usually grows to a height of three feet. When planted late, and in wet seasons, there is a tendency to go to weed, which is restrained by planting early, using fertilizers, and by working fast and early. The average yield of seed-cotton on fresh land is from 600 to 700 pounds to the acre, which is brought down to 400 pounds after five years' cultivation without manure. To make a 475 pound bale 1,485 pounds of seed-cotton are needed. The staple rates as middling from the fresh to low middling from the worn land, though there is usually very little difference in the quality. One-fourth of the land originally cultivated lies turned out, but after a rest of some years, especially if cattle have been kept off, if taken again into cultivation, it produces well. The damage from washings is not very great, and no efforts have been made to check it, except in a few instances, where horizontalizing and hillside ditching have been practiced with good results.

COFFEE.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

DALE.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

HENRY.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

ALLUVIAL REGION.

This region includes parts of Washington,* Clarke,* Mobile,* and Baldwin* counties.

WASHINGTON.

(See "Oak and Hickory Uplands, with Long-leaf Pine.")

CLARKE.

[See "Oak and Hickory Uplands, with Long-leaf Pine.")

MOBILE.

(See "Long-leaf Pine region.")

BALDWIN.

(See "Long-leaf Pine region.")

SECTION IV.

CULTURAL AND ECONOMIC DETAILS OF COTTON PRODUCTION.

ANSWERS TO SCHEDULE QUESTIONS.

[The Roman numerals used in the following answers refer to the regions as numbered in the reference table.]

These regions are—

I.—Metamorphic.
II.—Coosa and outlying valleys.
III.—Coal-fields.
IV.—Tennessee Valley.
V.—Oak and Pine Uplands, including—
1. Oak and Hickory Uplands, with Short-leaf pine.
2. Gravelly Hills, with Long-leaf Pine.
VI.—Central Prairie region, including—
Flatwoods.
VII.—Long-leaf Pine region, including—
1. Oak and Hickory Uplands, with Long-leaf Pine.
2. Lime-hills or Lower Prairie.
3. Open rolling Pine Woods and Lime-sink region.

TILLAGE, IMPROVEMENTS, ETC.

1. The usual depth of tillage (measured on land side of furrow), is three to four inches in all the regions.

2. The draft employed in breaking up is generally one horse or mule.

3. Subsoiling is practiced to some extent, and usually with good results, in regions I, II, III, and IV; rarely, if at all, in the last three regions.

4. Fall plowing is practiced to a limited extent in I, II, III, and IV, and with good effect in certain parts of the Tennessee valley; rarely, if at all, used in VI and VII. Where cotton is the chief crop, all the labor is required in

the fall for gathering. In VII the character of the soil is generally of such nature that fall plowing would not be remunerative.

5. Fallowing is practiced but little, if at all, except in small areas in regions II and III. Throughout the State, however, it seems to be very common for land to be "turned out" to rest, and not to be tilled while lying fallow.

6. Rotation of crops is practiced throughout the State, but not always in a systematic way. Where there is system, the usual order of crops is cotton from one to three or four years, then corn, followed by oats, or wheat, to be followed again by cotton. In regions V, VI, and VII cotton is generally the chief crop, and all the best and freshest land is devoted to its culture. In these regions it is no unusual thing for the same lands to be planted in cotton five, ten, or fifteen years in succession. In some parts of the Tennessee valley it is becoming quite common to sow clover with small grain, so that the order of crops is cotton, corn, oats, or wheat, with clover, followed by one or two years' of rest.

7. In I, II, VI, and VII guano, the superphosphates, and compost, with cotton-seed and stable manure, or with lime, vegetable matter, etc., are chief manures, and the results are always good, provided the crops are properly cultivated. In II, IV, and V there is less use of commercial fertilizers, but on the contrary, cotton-seed and cotton-seed meal are used over a large part of this area to a very considerable extent. In all cases where fertilizers are properly applied and the crops are thoroughly cultivated, it appears that farmers are fully repaid for the outlay made in their purchase. There is but little green-manuring; but in some localities cow-peas, weeds, grass, etc., are turned under with advantage. On lime-lands pease cannot be profitably or safely used.

8. Cotton-seed is used throughout the State as a fertilizer, both in the green state and in the form of meal. It is also used in both forms as a feed for cattle; the cake or meal is, however, not yet much used for feeding. As an article of commerce seed is disposed of principally to the oil-mills, of which there are quite a number in this State. The negroes, as a rule, sell their cotton-seed to the mills, but the more thrifty and intelligent planters find it ad-

vantageous to return all surplus seed to the soil. The seed, both in its natural and manufactured forms, is especially valuable for corn and all small-grain crops. But, except some small areas, the cottonseed-cake is not much used either alone or mixed, for crops, probably because of its cost.

PLANTING AND CULTIVATING OF COTTON.

9. Throughout the State there is but little preparation given to land before bedding it for cotton, except the removal of the stalks of the old crop; but in exceptional cases the land is plowed broadcast in the winter or early spring. Cotton is uniformly planted in ridges, which are from two and a half to four feet apart, according to the strength of the soil. In regions I, II, III, and IV cotton is planted from the 10th of April to the 1st of May; in the other regions the time of planting is on the average from five to fifteen days earlier. There are numerous varieties of seed used. Among others may be mentioned Dixon, Boyd Prolific, Peeler, Zellner, Brown, Green, Petit Gulf, etc. According to some reports the cluster or short-limb varieties are best suited to deep soils, and long-limb varieties do best on light or thin soils. The average amount of seed required per acre is from two to three bushels, more being required for early than for late planting. It appears that in some cases the minimum may be as low as one bushel and the maximum as high as six bushels of seed per acre.

10. As a rule, the bed or ridge is opened with a narrow plow (scooter or bull-tongue), and the seed is strewn in the furrow by hand, and covered with a board, block, or harrow. Planters are but little used, and yet their use secures a uniform distribution of seed in the drill, and hence economizes seed, and also makes the after-cultivation more easy.

11. Seed comes up in from five to twenty days, and is usually thinned out to a stand when three or four weeks old, or when the third and fourth leaves appear. The young plant is sometimes retarded in growth by the "sore-shin," which is specially the case in cold and wet weather. The injury seems to be caused in the first instance from carelessness or want of skill in the use of the hoe, by which the

bark of the plant is either abraded or cut. The first after-cultivation consists in most cases, perhaps, in "running" round the cotton with a turning-plow, bar side to the drill, after which the cotton is chopped out and generally brought to a stand with one or two stalks in a hill, at distances varying from 12 to 18 or 20 inches in the drill, according to fertility of soil. After having been brought to a stand, cotton usually has simply surface culture with sweep, harrow, or cultivator.

12. The height attained before blooming is from one to three feet, according to the character and preparation of the soil. The first blooms appear when the cotton is eight or nine weeks old, and hence from June 10 to July 4, the former date being generally true for V, VI, and VII regions and the latter for the remainder of the State. The interval from the bloom to the opening of the boll is from 40 to 50 days, the shorter interval being required later in the season. Hence, cotton begins to open from the last of July to the middle of August, and picking usually begins two or three weeks afterward.

13. As a rule there are three pickings, by which all the crop is gathered. Picking generally closes by the last of November; but when the yield is heavy, or labor insufficient or inefficient, the picking may not be finished till Christmas. Black frost is said to occur from October 10 to the 1st of November, according to the nature of the locality and the character of the season. In some cases seed-cotton is penned in the field, which is generally quite hazardous. The usual practice is to have cotton ginned, if possible, as the picking progresses.

GINNING, BALING, AND SHIPPING.

14. There are many answers as to the gin used. Some of the many gins mentioned are Pratt's, Gullett's, Winship's, Orr's, Brown's, Carver's, Avery's, Loomis', Eagle, and Magnolia. In a few cases steam is the motive power, and still more rarely water is the agent. Generally horses or mules are used to drive the gin. The gearing consists usually of wooden cog-wheels or iron segments with pinion. The only

thing in the way of a general use of steam is the cost of engine and fixtures. Its use is of course advantageous in many respects. The great majority of the gins in use have from 40 to 50 saws.

15. In a day's run, from 1,000 to 8,000 pounds of clear lint can be made. The amount depends upon the number of saws in the gin, and also upon the motive power. A forty-saw gin, driven by a pair of mules or horses, will clean from 1,000 to 1,500 pounds in a day. The highest results are, however, to be gotten only with steam or water. The average amount of seed-cotton required for a 475-pound bale is about 1,545 pounds.

16. It appears that in large portions of regions IV and VII the wooden press still holds the place of honor; but in other regions iron presses of various patents are very generally in use. They seem to be specially in vogue in region VI, where Golding's, Allum's, Wright's, Stuckie's Hydraulic, Janney's, Bullock's Segment, and perhaps others, are enumerated. The number of bales pressed per day varies from five to twenty or twenty-five, according to the character of the press and the number of men employed. Iron ties are universally used, with various fastenings, such as Buckle and Loop, Arrow, American, Kennedy, the corrugated tie, etc. Jute and Kentucky or Missouri hemp and India bagging are used.

17. It is almost an invariable rule in Alabama to aim to make the bale weigh 500 pounds. Steamboats have imposed no limitation to the weight of a bale, but railroads usually charge by weight. Shipping begins as soon as cotton is ready for market, say the middle of October, and continues throughout the fall and winter. The port to which cotton is shipped is determined by the locality. There are good cotton markets at Mobile, Montgomery, Selma, Memphis, Tennessee, Rome, Georgia, and at various small towns within the State; and it is generally made advantageous to the farmer to sell near home. The rate of freight is determined in all cases by distance and means of transportation.

DISEASES, INSECT ENEMIES, ETC.

18. Cotton is injured by lice, flea-bugs, boll-worms, caterpillars, shedding and rust. Rust is caused on light sandy soils by excessive rains; on stronger lands, it is caused by the continuous planting of cotton for many years. Shedding is produced specially by continued and excessive rains. A wet season causes the loss of all the bolls that should have ripened during that period. In regions I, II, III and IV, the caterpillar generally makes its appearance so late, if at all, that its ravages are rather advantageous to the cotton, by stripping off the dense foliage, and thus insuring the prompt opening of all matured bolls; but in the other portions of the State, the caterpillar makes its appearance in multitudes, usually in August—early enough to be very hurtful to the crop. Lice, flea-bugs, and sore-shin generally appear (if at all) when the cotton is young, provided the weather is wet and cool. The boll-worm is not often very damaging, but may generally be found in the fields from the appearance of the first "squares" or "forms" till the first of September. Rust can be prevented by rotation or fertilizing. Shedding can be obviated to some extent by shallow plowing. In some localities, especially in some parts of regions V, VI, and VII, Paris green has been used to destroy the caterpillar, but, as it appears, with very little success in most cases.

19. Rust sometimes appears on heavy, ill-drained soils, but is oftenest seen on sandy lands, whether uplands or bottoms, on gray lands, on light-yellow clay lands, and in some places, as in Madison and Jackson counties, it is found often on fresh, loose lime-lands.

LABOR AND SYSTEM OF FARMING.

20. In regions I, II, III, and V, the farms are usually small, containing not more than 200 acres, but in some cases much larger. In the other regions, farms vary in size from 40 or 50 to 1,000 or even 2,000 acres. In the regions of small farms, supplies are largely raised at home, and there

is a reported increase of production. In the regions of large farms, on the other hand, there is in some localities increased production, but meat is still largely imported. In the middle and southern portions of the State, there is little or no wheat produced, and hence flour is almost universally imported into those sections.

21. The laborers are negroes and native whites, the former largely predominating in the regions of large farms, the latter on small farms, for most part. In the latter case, the laborer is generally the owner of the farm. Wages are paid in many ways, and at various rates, from forty to seventy-five cents per day, and from eight to fourteen dollars per month, to be paid at the end of the month.

22. The large cotton farms or plantations are almost altogether worked on the share system, the smaller farms being usually worked by the owners, with such hired help as may be needed on occasion. It is almost the universal practice on the large farms for the landlord to furnish everything but the laborers' board, and receive one-half of all the crops; but when only the land is furnished by the owner, he receives usually one-fourth of the cotton and one-third of the corn produced by the laborer. It is almost invariably reported that this system of cotton culture damages the quality of the cotton and deteriorates the land.

23. There is a very decided difference of opinion as to which is the better system (wages or share). With the exception of regions IV, V, and VI, opinions are about equally divided; in these, however, there is almost entire concurrence in the opinion that wages are the best. The reasons assigned in favor of wages are, that the laborer is sure of reward and a comfortable living, and the employer is enabled to control labor, and is justified in making larger expenditures in fertilizers, etc., to increase the yield. It is urged in favor of the shares system that the laborer is encouraged to make effort, and that if he is industrious and energetic, he will be rewarded with larger returns for his labor. On the whole, the condition of the laborers is good,

better perhaps than that of the same class of persons in any other quarter of the globe. Very few negroes own houses or lands in the large farming regions.

24. Cotton lands, in the greater part of the State, are estimated in value at three to ten and twelve dollars, while in a few localities, such as Perry, Marengo, etc., in region VI, and the best lands in the Tennessee Valley region, are estimated at fifteen, twenty, thirty dollars, and in some few cases even higher. Rent varies partly in proportion to the estimated value of the land, and hence the price of rent is from one dollar and less to two, three, and sometimes four dollars per acre. Rent is also paid in produce at the rate of one-fourth of the cotton and one-third of the corn grown on the land. According to the quality of land, the estimate of product per hand will will vary from two to six bales, but the average for good land is three to four bales per hand. In some cases, the estimate is made at six to ten bales per mule—*i. e.*, one mule and two hands.

25. In region I, credits to the value of one-half the laborer's crop are often made by the land-owner; in region II, credits are given largely in a few localities, but not as much as formerly; in region III, credits have only recently been asked and granted; in regions IV, V, VI, and VII, credits are almost universal, and regularly consume the entire crop of the laborer. As a rule, the crop is not insured till shipped or placed in the warehouse for shipment. In a few cases, cotton is insured when baled, and in some parts of Bullock county gin-houses and cotton are insured as soon as picking begins. Cotton is always insured when shipped, unless forbidden by the owner.

26. When the producer pays all the expenses of shipping, handling, storing, and commissions for selling, his expense or loss is from four to six dollars per bale, but when he sells to a home merchant, he often pays only for the weighing; the buyer incurs the additional expense. It is quite general over large areas of this State for the farmer to sell his cotton at the nearest town, store, or depot. The

report of cost of production is almost invariably eight cents per pound. A few seem to think that cotton can be produced at a cost of five or six cents, while a very few estimate the cost of production at ten to twelve and one-half cents per pound.

REFERENCE TABLE

—OF—

REPORTS RECEIVED FROM ALABAMA COUNTIES.

I.—METAMORPHIC REGION.

1. *Cleburne*—JOHN R. MOTIS, Edwardsville, March, 1880. Location, township 14, range 11, section 34. Describes first and second bottom lands of Cane creek.
2. *Cleburne*.—JAMES H. BELL aud DAVID V. CRIDER, Arbacoochee, April, 1880. Location, township 16, range 10, section 11. Describe bottom lands on creeks and on the Tallapoosa river.
1. *Randolph*.—JAMES H. RADNEY, Roanoke, April, 1880. Location, township 21, range 12. Describes first and second bottoms on Highpine and Cornhouse creeks.
1. *Lee*.—JOHN T. HARRIS, Opelika, August, 1880. Describes lands on Hallawaka creek and Chattahoochee river.
2. *Lee*.—C. H. MCCULLOH, Beulah, May, 1880. Location, township 20, range 29, section 20. Describes first bottom of Hallawaka creek and Chattahoochee river.
1. *Tallapoosa*.—D. A. G. Ross, Camp Hill, April, 1880. Location, township 21, range 24, sections 27 and 34. Describes bottom lands on Sandy creek.
2. *Tallapoosa*.—DANIEL TAYLOR, New Site, March, 1880. Location, township 24, range 23. Describes bottoms and uplands on Emuckfaw creek and Tallapoosa river.
3. *Tallapoosa*.—JAMES M. PEARSON, Dadeville, May, 1880. Location, township 22, range 23, section 36. Describes lands on Sandy creek.
1. *Clay*.—WILLIAM W. JENKINS, Hillabee, January, 1882. Location, township 20, range 7. Describes lands on Talladega, Buzzard, Hillabee, Hatchet and other creeks.
1. *Coosa*.—J. C. MCDIARMID, Good Water, April, 1880. Location, township 20, range 22, sections 24 and 25. Describes bottoms and uplands on Hatchet creek and Coosa river.
2. *Coosa*.—JOHN S. BENTLEY, Rockford. Describes bottoms and uplands on Socopatoy, Jacko and Big and Little Hatchet creeks, all tributaries of the Coosa river,

VI.—CENTRAL PRAIRIE REGION, INCLUDING FLATWOODS.

Sumter.—Dr. R. D. WEBB, Livingston, March 9, 1880. Describes the black prairie, the upland sandy, and the post-oak flatwood soils occurring in the drainage area of Sucarnatchie creek, a tributary of the Tombigbee river.

Greene.—THOMAS J. PATTON, Knoxville, July, 1880. Location, township 22, range 3 east. Describes uplands and lowlands on Sims and Buck creeks and the Warrior river.

1. *Hale.*—Professor TUTWILER, Greene Springs, May, 1880. Location, township 22, range 4 east. Describes lands on Five mile creek and Warrior river.
2. *Hale.*—NORFLEET HARRIS, Laneville, March, 1880. Location, township 18, range 5 east. Lands are for most part black and chocolate prairie.

Marengo.—W. A. STICKNEY, Faundsdale, June, 1880. Location, township 17, range 5 east, sections 8, 17, 20. Describes rolling and flat loose black prairie uplands, and mulatto or post-oak lands on and near Cottonwood and Powell creeks.

Perry.—H. A. STOLLENWERCK, Uniontown. Location, township 18, range 6, sections 18, 20. Describes first bottoms and rolling and level prairie lands on Dry Creek.

Dallas.—J. F. CALHOUN, Minter, February, 1882. Location, township 13, ranges 10, 11, sections 11, 14, etc. Describes uplands between Cedar and Pine Barren creeks.

1. *Lowndes.*—WILLIAM M. GARRETT, Mount Willing, March, 1880. Location, township 13, ranges 13, 14. Describes bottoms and black prairie and sandy uplands on Cedar creek.
2. *Lowndes.*—P. T. GRAVES, Burkville, September, 1880. Location, township 16, range 15, section 36. Describes uplands on Tallawassee and Pintlala creeks.

1. *Montgomery.*—THOMAS W. OLIVER, Montgomery, April, 1880. Location, township 16, range 18, sections 8, 18, 17. Describes bottoms on Small creek and uplands on Catoma creek.
2. *Montgomery.*—J. A. CALLAWAY, Snowdoun, March, 1880. Location, township 15, range 18. Describes bottoms and uplands on Ramer and Catoma creeks.

1. *Bullock.*—W. M. STAKELY, Union Springs, March, 1880. Location, township 14, range 23, section 4. Describes uplands and hog-wallow prairies on Cupiahatchee and Town creeks.
2. *Bullock.*—J. F. CULVER, Union Springs, January, 1880. Location, township 13, ranges 23, 24. Describes sandy and black prairie bottoms on the headwaters of Conecuh river.
3. *Bullock.*—J. L. MOULTRIE, Union Springs, March, 1880. Location, township 14, range 23, sections 23–26. Describes timbered prairie or post-oak lands on the Cupiahatchee creek.
4. *Bullock.*—M. L. STINSON, Union Springs, March, 1880. Location,

townships 11, 12, 13, ranges 23, 24. Describes bottoms and uplands on Conecuh and Pea rivers.

Macon.—JOHN L. COLLINS, Tuskegee, December, 1881. Refers to entire county.

1. *Barbour.*—Hon. H. D. CLAYTON, Clayton, September, 1880. Location, township 10, range 26, sections 4, 5, 8, 9. Describes first and second bottoms and rolling uplands on Choctawhatchee creek and river.
2. *Barbour.*—Dr. H. HAWKINS, Hawkinsville, March, 1880. Describes bottoms and uplands on Cowikee and other creeks, and on the Chattahoochee river.

VIII.—LONG-LEAF PINE REGION.

(Including: 1. Oak and Hickory uplands, with long-leaf pine. 2. Lime-hills or lower prairie. 3. Open pine woods and lime-sink region.)

1. *Washington.*—R. M. CAMPBELL, Saint Stephens, June, 1880. Location, townships 3, 4, 5, 6, 7, 8, range 1 east, and ranges 1, 2 west. Describes bottoms and alluvial lands on the Tombigbee river, and rolling and level uplands on Lewis and Sinta Bogue creeks.

1. *Monroe.*—J. M. HARRINGTON, Newton Academy, July, 1880. Location, township 9, range 9, section 16. Describes bottoms and uplands on Flat creek.

1. *Wilcox.*—HENRY C. BROWN, Camden, January, 1880. Location, township 12, range 8, section 33. Describes bottoms and uplands on Pursley creek.
2. *Wilcox.*—FELIX TAIT, Camden, April, 1880. Location, township 11, range 7. Describes lands on the Alabama river.

1. *Conecuh.*—ANDREW JAY, sr., Jayvilla, February, 1880. Location, township 5, range 12, section 30. Describes lands on Murder creek and Escambia river.
2. *Conecuh.*—P. D. BOWLES, Evergreen, February, 1880. Location, township 5, range 11, section 11. Describes bottoms and uplands on Beaver creek and Conecuh river and alluvial plains on Murder creek.

Crenshaw.—GEORGE W. THAGARD, Rutledge, January, 1880. Location, townships 9, 10, range 17. Describes bottoms and uplands on Patsaliga river.

Coffee.—M. G. STOUDENMEIER, Elba, July, 1880. Describes rolling and level lands on Boles creek and Pea river.

Dale.—J. C. MATHEWS.—Crittenden's Mills, January, 1880. Location, townships 3 to 8, ranges 23 to 28. Describes bottoms and uplands on Choctawhatchee river and several tributary creeks.

Henry.—A. MCALLISTER, Shorterville, March, 1880. Location, township 7, range 29. Describes bottoms on Choctawhatchee and uplands on numerous creeks.

Mobile.—J. P. STEELE, Citronelle, June, 1880. Describes lowlands and uplands on Mobile and Tombigbee rivers.

Escambia.—JOHN W. STEPHENSON, Douglasville, April, 1880. Location, townships 1, 2, ranges 11, 12. Describes lands on Conecuh river.

Geneva.—W. N. BRANDON, Geneva, August, 1880. Location, townships 2, 3, ranges 22, 23. Describes bottoms and uplands on Wilkinson creek.

NOTES.

To page 178.—Stratified Rocks of the Jura-Trias are not known in Alabama; but the trap dykes of the Metamorphic Region are usually referred to that age.

To page 196.—In Murphree's Valley the anticlinal structure is obscured, or rather, complicated, by a fault along the eastern side of the Valley, running approximately parallel with its length.

West of this fault, and over the greater part of the area of the Valley, the strata have generally a dip to the northwest. East of it, they stand usually nearly vertical, with southeast dip in a few localities.

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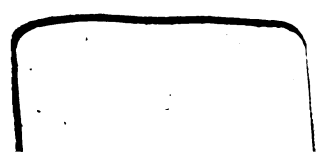
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